


Stone Fruit IPM for Beginners

A series of how-to-fact sheets for new stone fruit growers and scouts to protect stone fruit orchards from pests

Developed by the Great Lakes Fruit Workers, a work group of the North Central Integrated Pest Management Center

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Produced by members of the Great Lakes Fruit Workers in cooperation with Michigan State University Extension and Cornell Cooperative Extension. This work is supported by the USDA National Institute of Food and Agriculture, Crop Protection and Pest Management Program through the North Central IPM Center (2014-70006-22486).

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The fact sheets in this publication are available as PDFs at: **http://bit.ly/stone-fruit-ipm**

Published February 2019

Please note: This series of fact sheets will help you begin to understand and address the major stone fruit pests, but does not guarantee perfect fruit. These fact sheets and scouting guides are a compromise between the most accurate, complex information researchers have to offer and the amount of information a beginner can take in.

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Preface

Julianna Wilson, Michigan State University, Department of Entomology

What is IPM?

Integrated pest management (IPM) is a set of strategies and tactics agricultural producers use to manage crop pests. The goal of IPM is to increase production efficiency, reduce production costs, reduce worker and consumer exposure to pesticides and protect the environment to support sustainable production of marketable products.

Some examples of IPM practices used in stone fruit production include using pheromones to disrupt insect reproduction, using pest-specific pesticides to reduce harm to non-targets, scouting for insects and diseases and monitoring weather conducive to pest development to optimize the timing of IPM tactics.

Effective IPM programs rely on an understanding of pest biology in relation to the crop produced in a particular region. Fortunately, we already know a great deal about the biology of many key stone fruit pests (insects, mites and diseases) and the effective IPM strategies and tactics for managing them.

Purpose of beginning stone fruit IPM fact sheets

This series of fact sheets provides the basics on IPM tactics used against stone fruit pests; their use provides a foundation for successful pest management. Keep in mind not all the pests in this series will be problematic on every farm and in every season—that is why IPM scouting and monitoring strategies are important. Results may not prove perfect, because pests could show up in your stone fruit orchard that are not covered here.

Pest presence and severity will vary among orchards as a result of several factors including scion and rootstock susceptibility and production practices. Differences in pest pressure will also vary year to year in a given orchard as a result of interacting factors related to weather including carryover inoculum and overwintering success of pests.

These fact sheets represent a compromise between the most accurate, complex information researchers have to offer while maintaining an introductory context for beginning stone fruit producers and people training to become scouts in stone fruit orchards. Read the first chapters carefully to begin this new venture and follow the Scouting Calendars as they apply to stone fruit growth stages during the growing season.

MSU Extension file photo.

Adopting an IPM Mindset

1. Learn the common insect and disease issues likely to arise in the crop, when they are most likely to be a problem and what tactics can be used to provide early detection and prevention.

- ► For most diseases, successful IPM relies on selecting disease-resistant cultivars where possible, using cultural practices that remove or destroy sources of inoculum, and applying preventative sprays according to weather-based predictive models.
- ► For insects and other arthropod pests, success requires learning the biology of the main pests and, in particular, which life stage can be disrupted or suppressed, and when and where it is likely to be active.

2. Find out what strategies are recommended for keeping pest issues managed below economic thresholds.

► The *economic threshold* is the level of a pest population or extent of crop damage at which the value of the destroyed crop is more than the cost of pest control.

► The level of fruit damage allowed at harvest will depend on the grower's tolerance and the markets where the fruit will be sold, however, a healthy orchard will stay productive longer than one that is stressed by infection or damaged by pests.

3. When a problem arises, **identify the correct cause.**

► Use available scouting guides, submit samples to plant diagnostic services or consult experienced field scouts.

► Keep an eye out for regional or local disease and insect reports so that you know what is being found nearby in a given week during the season.

4. If you can't bring the expert out to the field, **document the signs and symptoms.**

► Take clear photos or collect fresh samples, and provide information about the orchard including its age, the cultivar affected and the production system being used.

5. Use the correct tools and apply them at the right time for the target issue.

► Passive (unbaited) traps may be useful for some pests, but pheromone lures are available for many insect pests. Depending on the pest, they may be used: (1) to lure pests to a trap for monitoring by recording their presence or absence, (2) for counting pests up to an action threshold, or (3) for mating disruption.

► Pesticides come in a variety of different formulations and act in different ways, including how long they are able to persist on the plant providing protection, so it is important to know which classes and formulations are best for the target pest and when they should be applied and reapplied for maximum effect.

6. Keep good records on individual orchards.

► Pests can be very patchy and unpredictable, but keeping records on individual orchard blocks will help with anticipating potential problems or problem areas from year to year.


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Chapter 1

Introduction

Julianna Wilson, Michigan State University, Department of Entomology

What does it take to grow stone fruit?

Growing stone fruit can be very rewarding, but also expensive and time consuming. There are many things that must be done in a timely manner to produce edible, attractive and marketable fruit. This series of fact sheets will focus on overcoming pests that challenge stone fruit growers in their new orchards, but many of the same principles and practices apply in established orchards. The intended audience for these fact sheets is new stone fruit growers or people training to become an orchard scout in stone fruit orchards.

Throughout the series, critical practices—"Must Do's" —are highlighted. If these critical practices are not done in a timely manner, there will be very little useable fruit despite your best efforts. Look for the △ symbol throughout this series for the essential management practices required for successful stone fruit production. This introduction contains a brief summary of what it takes to produce stone fruit for sale.

△ **Must Do: Determine your market.** Will you sell direct to consumers through a farm stand on your property or at local farmers markets? Will you have a U-pick operation? Will you sell to a regional processor or packer/shipper? Different cultivars are more or less suitable for different markets. The MSU Product Center can help develop a business and marketing plan (http://www.canr.msu.edu/productcenter/).

△ **Must Do: Identify, acquire and prepare an appropriate site.** Identify your dominant soil type. Stone fruit need a well-drained site. Seasonal high water tables in spring and fall can kill trees outright. To check this, dig a few holes about 2 feet deep. Gray mottling in the soil profile indicates seasonal water logging. Test the soil to determine pre-plant fertilizers for correct pH, lime, calcium, phosphorus and magnesium. Use an appropriate cover crop to break up compacted soil, add green manure and suppress suspected soil-borne pathogens or nematodes, especially when planting back into old orchard rows. Controlling patches of noxious perennial weeds before planting the new orchard will save a lot of headaches in the future.

Also, select a site that allows cold air to drain away from the orchard—sloping sites are generally preferred for this reason. Stone fruit are some of the earliest blooming of the tree fruit in spring and can be susceptible to frost and cold injury. Peaches in particular can be injured by extreme cold events and are generally considered to be short-lived orchards in the Great Lakes Region. For high value cultivars, consider investing in frost fans to aide in mixing inversion layers and minimizing damage from cold snaps in spring.

△ **Must Do: Choose the appropriate stone fruit suitable for your region, site and available market.** Choosing which varieties to grow might be based in some part on personal taste, but in reality, the focus should be on what your target market will buy. Disease-resistant cultivars will be essential in organic production systems.

△ **Must Do: Purchase the necessary equipment to maintain your orchards.** The proper equipment and training will be needed for applying pesticides (whether you are using synthetic or naturally-derived), pruning, harvesting and other orchard maintenance. Determine the labor that will be needed to accomplish all of these tasks and whether there will be enough of it when needed.

△ **Must Do: Learn as much as you can about the horticultural requirements of your stone fruit orchard.** Different kinds of stone fruit will have different requirements for planting depth, irrigation and nutrient management, practices to maximize crop load and fruit size (e.g., pruning/training systems, fruit thinning), harvesting (e.g., hand harvested versus mechanical), post-harvest handling and storage, and other horticultural practices. Stressed trees are more prone to infection and invasion by pests.

△ **Must Do: Protect the crop from pests, including wildlife.** This series focuses on insects and diseases, but you will also have competition from wildlife and weeds.

Deer will severely stunt growth in fruit trees by eating buds and rubbing bark with their antlers. If you have deer in your neighborhood, protect new plantings by using repellents or an 8-foot fence, which is most effective. If deer find the trees before repellents are applied, you will have a constant battle to protect against stunted trees and reduced yields.

Voles and *rabbits* also chew bark, girdling trees, especially under the cover of snow in winter or in tall weeds during the growing season. To deter small rodents, apply wire mesh guards around young trees, but do not allow the guards to collect leaf debris as these favor trunk-boring insects. Keeping tree trunks free from weed growth also reduces habitat for these small pests.

Birds can be a significant pest of cherries as they begin to ripen, particularly in a dry season. There are a variety of different deterrents available to use including noise canons, pre-recorded bird calls of birds in distress or predatory birds. Some growers install nesting boxes for birds of prey to encourage natural predation of fruit-feeding birds and rodents.

Weeds provide cover for pests and can compete with young trees for water and nutrients when they are directly under the crop canopy. Weeds may also act as carriers of viruses that can be transmitted through insect vectors like leafhoppers when they feed on the crop after feeding on an infected weed host. On the other hand, carefully using cover crops in drive rows will help retain soil, prevent run-off and even increase soil fertility over time.

William Shane, MSU Extension

A peach pecked by birds.

Acknowledgements: This information was adapted with permission from “Apple IPM for Beginners,” edited by Deborah I. Breth, Cornell Cooperative Extension Lake Ontario Fruit Program.


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Chapter 2

Setting Up for Success

Julianna Wilson, Michigan State University, Department of Entomology

Good orchard pest control is complicated and challenging to learn.

Take the sustainable integrated pest management approach

Whether you are growing stone fruit under a conventional or organic system, consult a "Scouting Calendar" to determine what pest issues are present at each developmental stage, and what action to take to prevent damage. Insect and disease pest severity depends on the weather and site. Not all pests listed in this series will be problems in all sites, neither is this an all-inclusive list of pests that can threaten stone fruit in your area.

△ **Must Do:** Read and follow all required pesticide labels. Again, whether you are using synthetically- or organically-derived materials, it is imperative to follow the label to guide how much to apply, when to apply and what safety equipment is needed while mixing and spraying. The label will list which crops can legally receive applications of a particular pesticide, which pests it is meant to control, the necessary rate and the timing.

In the "Agricultural Use" box on the label, you will find the amount of time needed to wait to re-enter the sprayed area (REI). Under the label's "Crop Use" section, you will find how long to wait before harvesting the crop after the spray is applied, which is also known as the preharvest interval (PHI) and whether there are special restrictions for use in a U-pick operation.

Recommended tools

- ► 10x hand lens or "optivisor" (3x magnifier)
- ► Pocket knife
- ► Pruners, loppers or other implements for removing diseased limbs
- ► Spray bottle of disinfectant to sanitize tools in between cuts
- ► Small assorted bags for containing samples (e.g., recloseable plastic and paper)

- Insect monitoring traps and pheromone lures as per specific target pest
- Accurate minimum/maximum thermometer protected from direct sun or shade
- Rain gauge or weather station (depending on the size and topography of your operation, you may want more than one)
- Sprayer that can provide good spray coverage throughout the tree
  - Orchard spray materials
  - Learn how to safely apply pesticides in an orchard by training to become a pesticide applicator.
    - If you plan to use restricted use pesticides (RUPs), you will need to take a test to become a certified pesticide applicator; each state or province has their own requirements for becoming licensed to apply RUPs.
  - Learn where to find current pesticides labels for the products you intend to use and keep them handy, either by printing them out and putting them in a folder that is easy to access or by keeping digital files in a folder on your virtual desktop.
- Personal protective equipment to spray pesticides available from grower supply companies, your pesticide supplier or a local hardware store.
- A computer or mobile device with Wi-Fi access to monitor weather and use online tools related to disease prediction, insect pest development and irrigation recommendations (see Section 4 for more details).
  - In Michigan and Door County Wisconsin, www.enviroweather.msu.edu is the place to find weather-based pest management tools.
  - In Connecticut, Massachusetts, Minnesota, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Vermont and Virginia, locate a NEWA weather station near you at http://newa.cornell.edu and use it for weather-based pest management tools.

Resources for keeping current on orchard IPM

- Attend spring and summer field meetings, winter fruit schools, conferences and trade shows that provide crop-specific sessions on current topics related to growing and marketing stone fruit.
  - For more information on programs in Michigan, visit http://msue.anr.msu.edu/topic/info/fruit.
  - For more information on programs in New York, visit: https://nysipm.cornell.edu/agriculture/fruits/cce-programs.
- Subscribe to your state Extension fruit newsletter or blog for daily and weekly time-sensitive updates from specialists and Extension educators in your region.
  - In Michigan, the MSU Extension "Fruits and Nuts" newsletter at http://msue.anr.msu.edu/topic/info/fruit offers a regular news digest delivered to your email inbox when you sign up for free, including weekly regional reports during the season.
  - In New York, Cornell Cooperative Extension fruit programs offer daily or weekly time-sensitive updates through the Lake Ontario Fruit Program at https://lof.cce.cornell.edu or Eastern New York Commercial Horticulture Program at https://enych.cce.cornell.edu. Also, "Scaffolds" Fruit Newsletter at http://www.scaffolds.entomology.cornell.edu provides weekly updates on crop and pest development, along with background biological information and management guidelines.
- Subscribe to trade journals such as the Fruit Quarterly, Fruit Grower News and Good Fruit Grower.
- Apps for keeping spray records
  - Trac Cherry, Trac Stone Fruit Apps
  - Fruit Tracker in Ontario
  - Orchard Max app
- Publications
  - Airblast 101 https://sprayers101.com/airblast101/
  - Common Tree Fruit Pests (NCR063) – A.H. Howitt. Search at http://shop.msu.edu

- Tree Fruit Field Guide – A. Agnello et al. http://palspublishing.cals.cornell.edu/nra_order.taf?_function=detail&pr_id=158
- Compendium of Stone Fruit Diseases - J.M. Ogawa et al. https://my.apsnet.org/ItemDetail?iProduct-Code=41744
- Michigan Fruit Management Guide (E0154) - MSU Extension. Search at http://shop.msu.edu
- Fruit Crop Ecology and Management (E2759) Search at http://shop.msu.edu
- IPM in Practice – M. L. Flint. http://anrcatalog.ucanr.edu/Details.aspx?item-No=3418

Where to find help

► Find contact information for local Extension offices and fruit Extension staff that can provide support services and guidance on educational opportunities—and keep it handy.

- In Michigan, use the "Find an Expert" tool on the MSU Extension Fruit and Nuts page to find the fruit Extension educator nearest you (http://msue.anr.msu.edu/topic/experts/fruit).
- In New York, use http://cce.cornell.edu/localoffices to locate your nearest fruit Extension person.

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Chapter 3

Scouting Calendars

Julianna Wilson, Emily Pochubay and Bill Shane, Michigan State University

Use scouting calendars for better management decisions

Scouting to monitor for pests that may cause damage to fruit crops is a key component for making management decisions and using online tools supporting IPM. Scouts use a number of tools to track pests, many of which were noted in Chapter 2.

A scouting calendar can assist scouts by helping them predict when particular pests and which life stage of pests will be present in orchards during the season. These calendars and scouting reports can be used to decide which action to take (if any) to prevent damage. Not all pests listed in the calendars will be problematic in all sites, nor is this list an all-inclusive list of stone fruit pests.

Cherry and plum scouting calendar

Growth stage and approximate dates	Pest actions
Dormant (December – March) Sweet cherry  Tart cherry  Plum 	► Prune out cankers caused by **bacterial canker** when trees are dormant. Delay pruning to March for young trees and older trees that are weak. Copper-based materials may be applied before trees break dormancy. ► **Black knot** (plums): Prune out and burn all knots, cutting at least 6-8 inches below visible swellings. ► **Mites** and **scale insects**: Apply dormant oil to smother overwintering life stages of these pests.
Swollen bud (mid-late April) Sweet cherry  Tart cherry  Plum 	► Prune out cankers caused by **bacterial canker** during periods of dry weather. Apply reduced rates of copper to avoid phytotoxicity. ► Scout for and apply insecticide as needed for **aphids** and **climbing cutworms**. ► Dormant oil may still be applied for **mites** and **scale insects** to smother overwintering life stages of these pests. *Note: When green or bloom tissue are present, be careful with chemistries that may be phytotoxic.*

Cherry and plum scouting calendar

Growth stage and approximate dates	Pest actions
Bud burst/green tip (late April) Sweet cherry  Tart cherry  Plum 	► Deploy monitoring traps for **insect pests**. ► In plums, apply fungicide against **black knot.**
White bud/popcorn (early May)* *Sweet cherry is pictured. Phenology is similar for sweet cherry, tart cherry and plum. 	► Apply fungicide for **brown rot** especially for sweet cherry. ► Scout for **green fruitworm** and consider insecticide application if populations are high.
Bloom (mid-May)* *Sweet cherry is pictured. Phenology is similar for sweet cherry, tart cherry and plum. 	► Apply fungicide for **brown rot** (cherry and plum), **cherry leaf spot** (cherry) and **black knot** (plum) prior to possible infection periods or if wet, rainy weather prevails. ► Frost/freeze, cold and wet weather favors **bacterial canker** (sweet cherry). A copper spray may be warranted in these conditions.
Petal fall (mid- to late May)* *Sweet cherry is pictured. Phenology is similar for sweet cherry, tart cherry and plum. 	► Apply fungicide for **brown rot** (cherry and plums), **leaf spot** (cherry and plums) and **black knot** (plums) prior to possible infection periods. ► Scout for and apply insecticide as needed for **plum curculio, mites, aphids, green fruitworms** (cherry)**, leafrollers, American plum borers, oriental fruit moth** (plums) (if not using mating disruption), **leafhoppers** and **San Jose scale**.

Cherry and plum scouting calendar

Growth stage and approximate dates	Pest actions
Shuck split/fall (late May)* *Sweet cherry is pictured. Phenology is similar for sweet cherry, tart cherry and plum. 	► Apply fungicide for **brown rot** (cherry and plums), **leaf spot** (cherry and plums) and **black knot** (plums) prior to possible infection periods. ► Scout for and apply insecticide as needed for **plum curculio** (cherry and plum)**, leafrollers** (sweet and tart cherry) and **black cherry aphids** (sweet cherry).
First cover (early to mid-June)	► Apply a fungicide or combination of fungicides effective against **brown rot, cherry leaf spot** (prior to possible infection periods) and **black knot** (plum) or **powdery mildew** (cherry). ► Scout for and apply insecticide as needed for **black cherry aphids** (sweet cherry), **plum curculio, leafrollers**, **peachtree borers**, **rose chafers** and **San Jose scale**.
Second cover (mid- to late June)	► Apply fungicide or combination of fungicides effective against **cherry leaf spot** and **brown rot** prior to possible infection periods. ► Scout for and apply insecticide as needed for **black cherry aphids** (sweet cherry), **leafrollers, rose chafers** and **peachtree borers.** ► For sweet and tart cherry, if any **spotted wing Drosophila** have been caught in traps and fruit are at the straw color stage, use an insecticide or combination of insecticides to target this pest as well.
Third cover (early July) to pre-harvest (mid-July – early August)	► Apply fungicide or combination of fungicides effective against **cherry leaf spot** and **brown rot** prior to possible infection periods. ► Scout for and apply insecticide as needed for **apple maggots/ cherry fruit flies, leafrollers, rose chafers, mites, Japanese beetles, leafhoppers, aphids** and **scale insects.** ► In sweet and tart cherry, use an insecticide that is effective against **spotted wing Drosophila.** To prevent infestation by this pest in plum, harvest fruit before it softens to 3.5 pounds firmness, as measured with a penetrometer fitted with a 7.9 millimeter tip.
Post-harvest (mid-August)	► A fungicide for **cherry leaf spot** may be needed at this timing if the season has been particularly wet and conducive for cherry leaf spot development (tart cherry).

Peach and nectarine scouting calendar

Growth stage and approximate dates	Pest actions
Dormant (December – February) 	► **Valsa canker** is assisted by cold injury when it infects trees. Cultural practices to harden off trees by fall are important in reducing cold injury. These include late spring pruning, avoiding excess fertility and planting an early cover crop (by July 4) in clean, cultivated orchards. ► Sprays to prevent **peach leaf curl** and **bacterial spot** are applied in autumn after leaf drop or in spring before bud swell.
Delayed dormant (March – April)	► For varieties not resistant to **bacterial spot**, follow the season-long recommendations in E-154; in high pressure years (e.g., seasons with extended wet periods that induce water congestion in leaves) and on sandy sites, this disease will be very hard to control on susceptible varieties. ► Dormant oil application is used to smother the overwintering life stages of **San Jose scale** insects. ► Scout for and apply an insecticide as needed for **climbing cutworms.**
Swollen bud (mid- to late April) 	► Continue maintenance sprays for **bacterial spot** in susceptible cultivars. ► **X-disease** prevention begins with scouting and removing chokecherry bushes within a 500-foot radius of a stone fruit orchard. April is a good timing to do this because chokecherry bushes are easier to spot when they are in bloom. ► It is still safe to apply dormant oils for **mites** and **scale** insects. *Note: Do not apply chemistries that may be phytotoxic when flower buds and green leaf tissue are present.*
Pink (late April to early May) 	► Prune out dead wood and cankers caused by **valsa canker** when trees are at the pink stage or later to allow rapid healing. When removing entire limbs, leave a stub that is between 0.25 and 0.5 inch. Remove cuttings from orchard and burn as soon as possible. ► This is also the time to start culling trees with symptoms of **x-disease**. Burn the trees after removal. ► Continue maintenance sprays for **bacterial spot** in susceptible cultivars. ► Consider fungicide application for **American brown rot**. ► For **green fruitworm** and **tarnished plant bug**, consider insecticide application if populations are high. ► Deploy pheromone dispensers for **oriental fruit moth** mating disruption.

Peach and nectarine scouting calendar

Growth stage and approximate dates	Pest actions
Bloom (mid-May) 	► Continue maintenance sprays for **bacterial spot** in susceptible cultivars. ► Apply fungicide for **American brown rot**. ► Apply fungicide for **powdery mildew or rusty spot** if growing a susceptible cultivar.
Petal fall (mid- to late May) 	► Continue maintenance sprays for **bacterial spot** in susceptible cultivars. ► Apply fungicide for **American brown rot** and **rusty spot** if growing a susceptible cultivar. ► Apply insecticide for **oriental fruit moth** if not using a mating disruption. ► Scout for and apply insecticide as needed for **rose chafers, tarnished plant bugs, green peach aphids, thrips, leafrollers** and **San Jose scale**.
Shuck split/fall (late May) 	► Continue maintenance sprays for **bacterial spot** in susceptible cultivars. Avoid using copper-based materials at and after shuck-split to prevent phytotoxicity injury. ► Apply fungicide for **American brown rot**, **rusty spot** and **peach scab**. ► Apply insecticide as needed for **plum curculio, oriental fruit moth** (if not using mating disruption), **rose chafer, San Jose scale, lecanium scale** and **tarnished plant bug**. San Jose scale crawler stage is approximately seven to 10 days after shuck split.

Peach and nectarine scouting calendar	
Growth stage and approximate dates	**Pest actions**
First cover (early- to mid-June) 	► Continue maintenance sprays for **bacterial spot** in susceptible cultivars. ► Scout for and cull trees with symptoms of **x-disease.** ► Apply a fungicide or combination of fungicides active against **American brown rot**, **peach scab**, and **powdery mildew or rusty spot** (if growing a susceptible cultivar). ► Apply insecticides as needed for **oriental fruit moth** (if not using mating disruption), **tarnished plant bugs** and **rose chafers**.
Second cover (mid- to late June)	► Continue maintenance sprays for **bacterial spot** in susceptible cultivars. ► Apply a fungicide or combination of fungicides active against **peach scab** and **powdery mildew or rusty spot**. ► Apply insecticide as needed for **oriental fruit moth** (if not using mating disruption) and **lesser peachtree borer.**
Third cover (early July) to pre-harvest (mid-July – early August)	► **Valsa canker** requires cold injury to infect trees. In clean-cultivated orchards, sow a cover crop around July 4 to help prevent cold injury later. ► Continue maintenance sprays for **bacterial spot** in susceptible cultivars up until three weeks prior to harvest. ► Apply a fungicide or combination of fungicides active against **American brown rot** and **peach scab.** ► Apply insecticide as needed for **oriental fruit moth** (if not using mating disruption), **lecanium scale**, **peachtree borers, twospotted spider mites, Japanese beetles**, **thrips, leafrollers, tarnished plant bugs** and **brown marmorated stink bugs.**
Post-harvest (mid-August)	► Scout for and cull trees with symptoms of **x-disease.**


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Chapter 4

Importance of Weather for Predicting Pests

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Precipitation and humidity

Monitoring rain events and humidity is critical for understanding disease development and implementing effective disease management tactics. Initial release of fungal spores in spring is often triggered by rain. In addition, rainwater spreads inoculum of fungal and bacterial diseases in the orchard and favors infection of susceptible plant tissue.

Depending on the growth stage, the plant and crop may be susceptible and at high risk to infection during rain events if unprotected. Once infection occurs, most bactericides and fungicides cannot kill established diseases, which then produce inoculum leading to more disease and crop loss. Bactericides and fungicides (whether synthetically or naturally derived materials) are most effective when used as protectants against diseases, meaning the protectant material is applied prior to wetting events to prevent the infection. Therefore, stone fruit growers must track forecasted rain and wetting events to apply protectants to susceptible plant tissues before rain, and reapply following wet weather that may have washed off the fungicide or bactericide.

For insects and mites (arthropods), rain can wash off insecticides that were applied, leaving the tree or fruit vulnerable to attack. Therefore, if the target pest is still active and the plant is still at a stage that is vulnerable to attack from that pest, be prepared to reapply insecticides after rain events. The level of rainfall can variously impact arthropod populations: overly dry conditions favor mite buildup whereas rainy conditions promote shoot growth that encourages aphid infestations. Furthermore, the emergence of some insects, such as cherry fruit flies, is related to soil moisture following rain events at specific times during the growing season.

Temperature

Most developmental models for insects, mites, plants and some diseases use the concept of “degree-days” to predict when the pest is likely to occur and be vulnerable to management tactics, or when plant growth stages are likely to occur. Degree-days are a measure of the average heat accumulation above a base temperature over a 24-hour period, which is why they might also be called “daily heat units.”

Plants and their pests (insects, mites and diseases) are not warm-blooded, and their growth and development can be linked to a base temperature below which no development occurs. For insects, this is often 50 degrees Fahrenheit, unless otherwise noted, and is usually designated as DD base 50. Most organisms also have an upper temperature threshold above which development slows or stops and some models take this into account when calculating degree-days (this would be designated as DD base 86/50).

Seasonal degree-day accumulation above the known base temperature for a pest can help estimate the dates of its predicted occurrence and life stages in orchards. Daily heat units or degree-days can be calculated by taking the difference between the average daily temperature and the base temperature. To calculate accumulated degree-days for a timeframe, sum the daily degree-day values over the desired period of time. In temperate regions of North America, March 1 is often used as the start date to begin tracking degree-day accumulation. Alternately, some models use a start date based on a biological event, such as a particular plant growth stage (e.g., bud break), the first date the adult form of the pest is found in a trap, or the date some other life stage of the pest first appears in the orchard. This start date is called a “biofix.”

To calculate degree-days or daily heat units:

1. Record the minimum and maximum temperature for the day (use a minimum/maximum thermometer).

2. Average those temperatures.

3. Subtract the base temperature. If the difference is negative, record a “zero” for that day.

Acknowledgements: This information was adapted with permission from “Apple IPM for Beginners,” edited by Deborah I. Breth, Cornell Cooperative Extension Lake Ontario Fruit Program.

Example 1: Yesterday's high was 85 F and the low was 65 F. Average temperature = 75 F. Subtract the base temperature (50) and you have 25 degree-days accumulated that day. Add 25 to previous total starting at a specific date or biofix.

Example 2: Yesterday's high was 55 F and the low was 40 F. Average temperature = 47.5 F. This is less than the base temperature, 50 degrees, so 0 degree-days.

Sample table for recording degree days

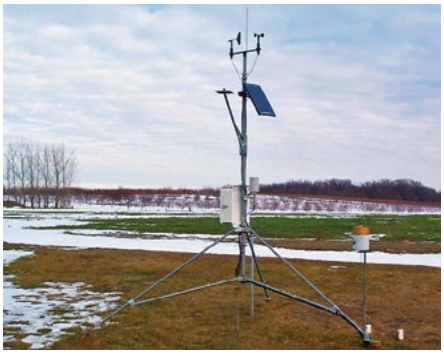
Create your own table or use this one.

Date	Max °F	Min °F	Precip.	*Degree days, daily and accumulated					
				Base 32 °F		Base 43 °F		Base 50 °F	

*Degree days = (Max temperature + minimum temperature)/2 – base temperature

IPM decision support tools

Tools for IPM decision support have been developed for some key pests that affect stone fruit. Enviroweather (www.enviroweather.msu.edu) in Michigan and parts of Wisconsin, NEWA (newa.cornell.edu) in New York and many states in the northeast, and private companies provide weather-based IPM tools for orchards. General tools include real-time weather observations, forecasts and summaries, degree-day calculators, soil conditions and irrigation scheduling.



MSU Enviroweather

An Enviroweather weather station collects data near an orchard.


Stone Fruit IPM for Beginners

Developed by the Great Lakes Fruit Workers and funded by a working group grant from the North Central Integrated Pest Management Center


Chapter 5

Guidelines for Safe and Effective Pesticide Use

Julianna Wilson, Michigan State University, Department of Entomology

What is a pesticide?

A pesticide is any material that is applied to a crop to protect it from pest damage or disease infection; this includes synthetically and naturally derived materials. If the material is used against an insect, it is called an insecticide. If the material is used against a disease, depending on the disease-causing organism it may be called a bactericide, fungicide or nematicide. If the material is used against weeds, it is called an herbicide. All of these are pesticides.

Pesticides will either be registered as “general use” or “restricted use.” To be able to apply restricted-use pesticides (RUPs), applicators must obtain the training and licensing required to use RUPs. Pesticide applicator licenses must be renewed through state or provincial agencies. Many growers obtain credits toward renewal by attending educational programs that offer RUP credits. Renewal can also be achieved by successful completion of a renewal examination offered by a state or provincial agency.

The label is the law

Reviewing pesticide labels is critically important! Labels list the active ingredients of a pesticide, the pesticide’s mode of action (i.e., key information for managing resistance), which crops it can be used on, the pests it targets, and how and under what conditions the product can be applied including what safety precautions are required. It is vital to thoroughly read the entire label and any supplemental information for the pesticides you consider using for crop protection before applying them.

Pesticides must only be used for the specifically listed purposes and in the manner described on the product label. Non-compliance with pesticide labels could reduce the product’s performance and may cause harm to humans, the crop and the environment. The pesticide label is legally binding and you are obligated by law to adhere to the instructions and information provided. Most pesticide labels are available to download as PDF files from the CDMS Label Database (http://www.cdms.net/Label-Database).

Select the right tools for the job

When you are selecting pesticides, select products that specifically list your crop and the pests you intend to control. Pay close attention to the preharvest interval (PHI) or days before harvest guidelines provided on the label; this information provides the required number of days that must pass between pesticide application and product harvest. Also, take note of the required personal protective equipment (PPE) listed on the label to ensure the application process is safe for human health.

Cory Outwater, MSU Tree Fruit Pathology

Always check the label for the required personal protective equipment such as boots, gloves, respirators or eye protection. These will vary depending on the toxicity of the pesticide.

The re-entry interval (REI) will inform you of how much time must pass after application before it is safe to re-enter the orchard. Pesticide products should be chosen based on the size of your farm, the quantity of available product, anticipated use and application rates, cost and product shelf-life.

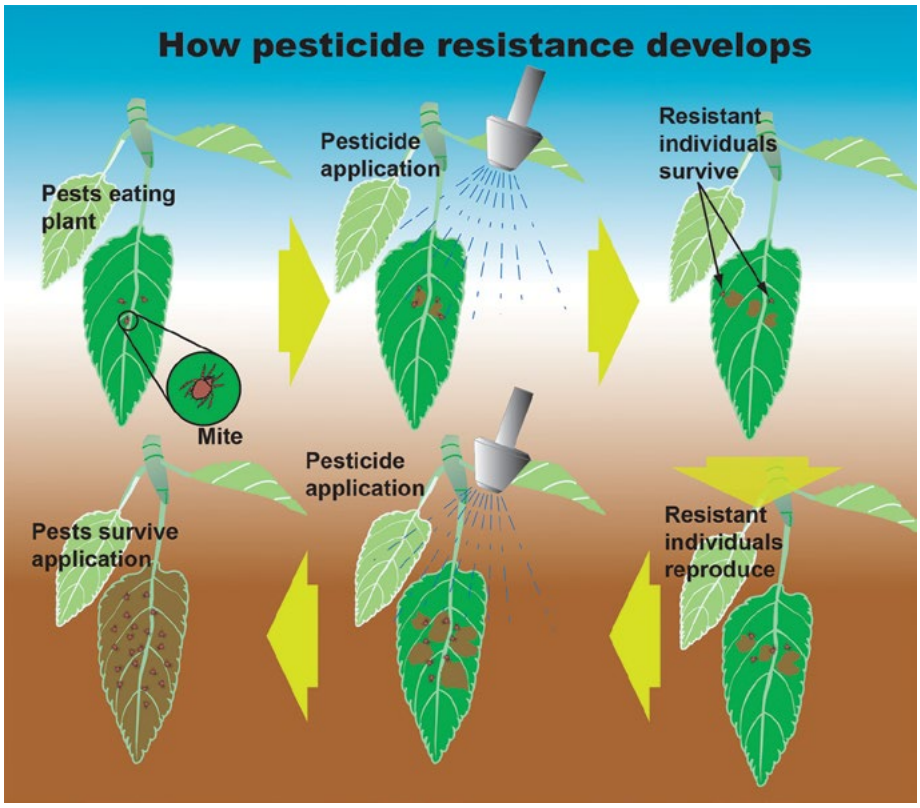
Beware of creating pesticide resistance

Pesticides are grouped by how they work against target pests, also known as their “mode of action.” A pest population repeatedly treated with pesticides having the same mode of action has a greater chance of having some members of its population emerge with resistance to that mode of action.

Over time, these resistant individuals can develop into an orchard-wide pest population that is resistant to that pesticide group. This renders any pesticide

that shares the same mode of action useless for managing the pests it was developed to target.

The key to resistance management is to alternate modes of action against a target pest population. Pay attention to the IRAC and FRAC group numbers on pesticide labels, follow the label directions to limit the amount of active ingredient applied and rotate different pesticide modes of action.



Sprayer calibration

To ensure good spray coverage and reduce pesticide waste and potential drift, it is critical to calibrate your application method to the particular orchard where pesticides will be applied. For more information and resources on sprayer calibration, including calibrating backpack sprayers for small plot work, check out http://sprayers101.com.

Optimal spraying weather

Applying pesticides under optimal weather conditions is essential for the effectiveness of the product and the reduction of environmental risks. Optimal weather for spraying occurs when the temperature is below 85 F, there is no rain forecasted for at least 6 hours and the wind is within 3-8 mph. Do not include oils within a spray 48 hours before or after freezing temperatures.

Tank mixes

If weather monitoring and scouting results suggest an insecticide and fungicide are needed, most growers will combine the two products in a “tank mix.” Tank-mixing requires knowing about the properties of the pesticides being mixed, whether they are compatible. Always read the label for information on tank-mix restrictions, as some tank mixes are toxic to trees or fruit and may cause damage.

Keeping good records

Any grower who applies restricted-use pesticides (RUP) is required by the 1990 Farm Bill to keep records of application practices and maintain these records for two years. The state of Michigan requires maintaining RUP records for three years. The first violation of this requirement results in a $500 penalty and up to $1,000 for any subsequent violations. However, in general it is a good practice to keep records of all pesticides used on a farm for a variety of reasons including tracking resistance management and to look back and know what was applied when there are questions about efficacy, drift or misapplications. For the purposes of keeping legal records, the following information about each application is required:

- EPA registration number of product
- Brand name of product
- Total amount of product used
- Crop, commodity or stored product to which the pesticide was applied
- Location of application
- Size of area where applied
- Month, day and year of application
- Name and certification number of the applicator (or applicator’s supervisor)

See an example of a record-keeping form that can be used to track pesticide applications.

Protecting pollinators and other beneficial insects

Pollination is the process where pollen from one flower is transferred to another flower, which is a basic requirement for almost all fruit production. Bees contribute about 80 percent of all insect pollination, so it is crucial to consider the safety of bees while

Pesticide use pesticide recordkeeping form example

Farm or business name and address: _____

Treated Area	Pesticide Information	Applicator Information
Date mo/day/yr:	Trade Name:	Name:
Crop:		
Location:	EPA Reg. Number:	
Size (acres):	Total amount applied*:	Certification Number
Notes:		

*The total quantity of the pesticide applied, such as pounds, pints, quarts, gallons, etc. of concentrated pesticides. Amount does NOT refer to the percent of the active ingredient (a.i.).

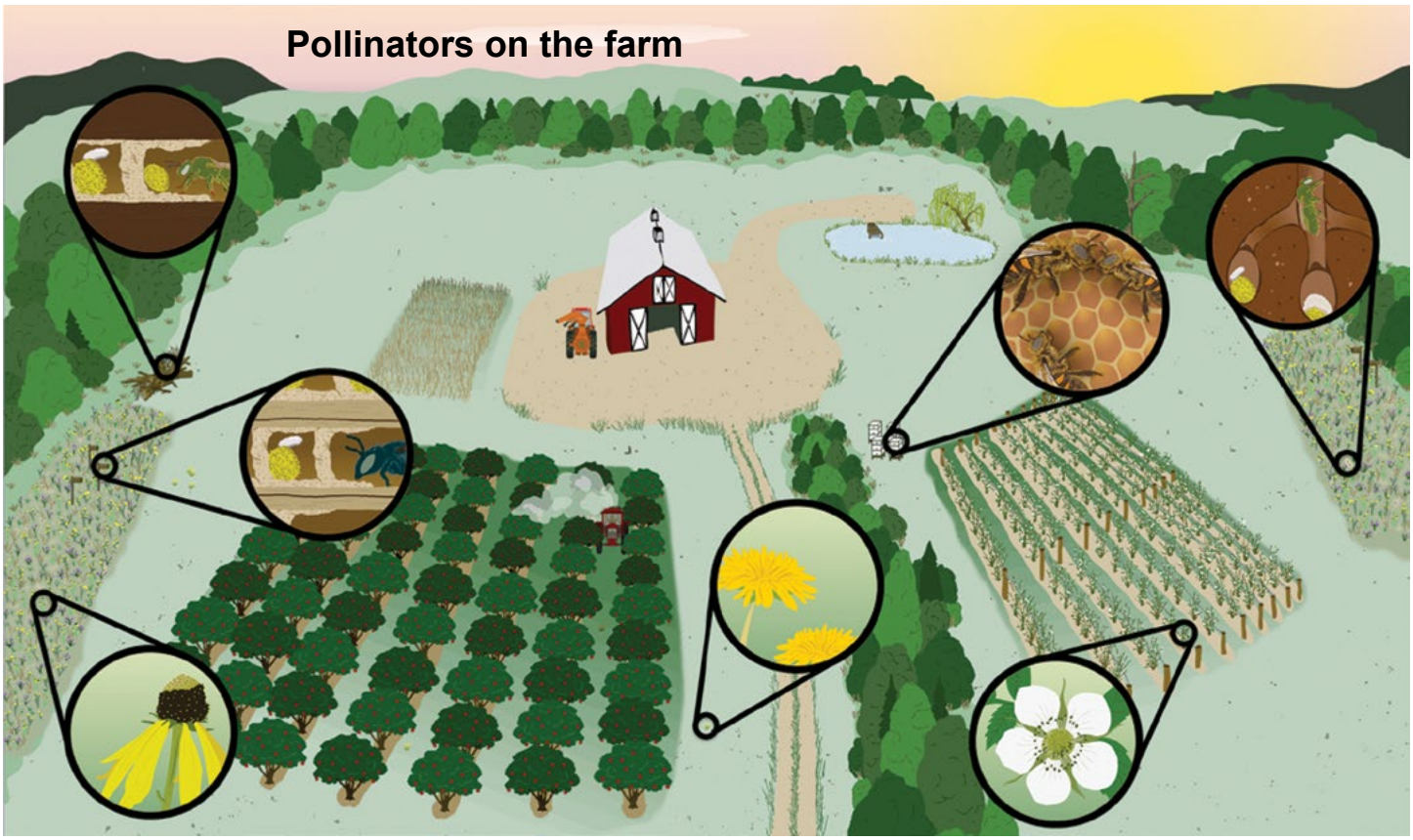
designing a pesticide program. Other insects such as natural enemies of orchard pests can be beneficial too. Parasitic wasps and lady beetles are examples of beneficial natural enemies.

Tips for reducing risks to bees and other beneficial insects:

► Use selective pesticides when possible and apply when needed as indicated by scouting for the pest and decision support tools where available.

► Most insecticides are restricted for use only before or after orchard bloom to protect bees. For pesticides allowed to be used during bloom, select formulations that are least toxic to bees:

- Granular insecticides are typically the least harmful to bees.
- Dusts are typically more harmful to bees than spray-applied materials.
- Wettable powders are typically more harmful than emulsifiable concentrates or water-soluble formulations.
- Avoid microencapsulated insecticides as they are extremely hazardous to bees.



Brett Blaauw, MSU Entomology

- When contracting with a beekeeper for pollination services, select a place on the farm where hives will be *up wind from* and *outside of* the orchard; honey bees can fly up to 2 miles from their hives, so there is no need to put them in harm's way to achieve adequate pollination. Otherwise, turn off the sprayer when driving by hives or contact the beekeeper in advance of the application so they have the opportunity to cover or move the hives if needed.
- When using insecticides before or after crop-bloom, mow the blooms of any flowering cover crops or weeds prior to spraying to drive pollinators out of orchards.
- Use drift control methods whenever possible and calibrate sprayers to apply the amount needed to get the job done without over-spraying.
- If possible, apply pesticides in the evening and avoid midday applications.

For more information on best management practices for protecting bees while achieving pollination in fruit crops, check out: bit.ly/MinimizeRisk4Bees

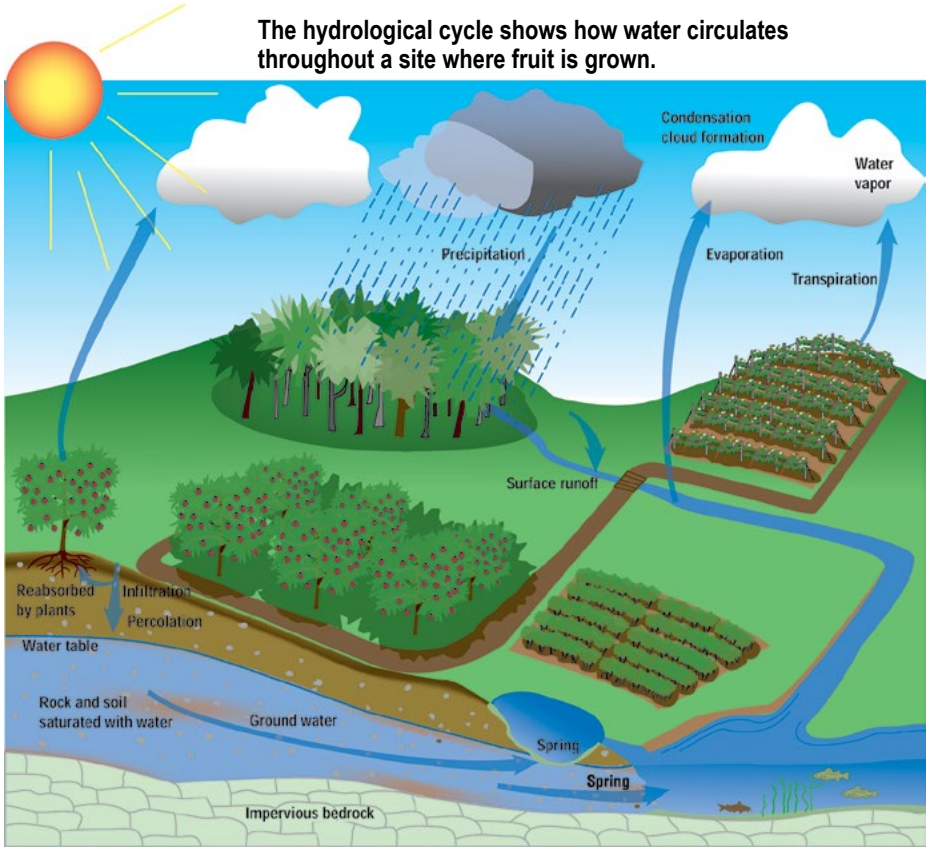
Protecting groundwater and wildlife

Pesticides can be harmful to vertebrates, such as fish and birds. Pesticides can affect birds through direct exposure to sprays, consuming treated crops or contaminated prey, and drinking contaminated water. Pesticides can enter water through drift, surface runoff, soil erosion or leaching, which can have negative effects on the safety of water resources and its aquatic inhabitants, as well as terrestrial wildlife utilizing the contaminated water. The Environmental Protection Agency (EPA) has determined threshold application rates that may impact species listed in the Endangered Species Act and provides this information on pesticide labels.

Tips for protecting groundwater and wildlife

- Calibrate equipment accurately and often.
- Carefully measure concentrates when preparing your spray tank.
- While filling a spray tank, ensure the end of the hose is above the water level to prevent back-siphoning.
- Clean up spills quickly and efficiently with an absorbent material, such as cat litter.
- Obey laws regarding disposal of pesticide wastes.
- Store and mix pesticides away from water sources.
- Delay pesticide application if expecting a heavy rain event.
- Do not spray when wind speeds exceed 8 mph, otherwise use drift control methods whenever possible.
- Reduce soil compaction; compacted soils increase the risk of run-off.
- Plant vegetative buffer strips around water ways to reduce erosion and run-off. Many states and provinces have cost-share programs to off-set the cost of installing buffer strips; in some areas, flowering plants can be seeded into buffer strips for the added benefit of providing food for wild bees and other beneficial insects when the crop is not in bloom.
- Consult the state or provincial Department of Natural Resources (DNR) or the Fish and Wildlife Services (FWS) to see if there are endangered species in your area that require special pesticide handling or added restrictions.

The hydrological cycle shows how water circulates throughout a site where fruit is grown.



Used with permission from *Fruit Crop Ecology and Management*, MSU Extension E-2759

Chapter 6

American Brown Rot

Emily Pochubay, Michigan State University Extension

American Brown Rot

Monilinia fructicola

Hosts

Nectarine, peach, plum, prune, sweet cherry, tart cherry

Time of Concern

Bloom to petal fall; preharvest

Damage, symptoms and disease cycle

The American brown rot fungus infects nectarines, peaches, plums, prunes, sweet cherries, tart cherries and other stone fruit. American brown rot infection is typically a preharvest concern as fruit begin to ripen and increase in sugar content. Under ideal conditions, American brown rot infection can also be a concern at pre-bloom (white or pink bud stage) through bloom, causing blossom blight and infecting spurs and woody tissue.

The American brown rot fungus overwinters in mummified fruit, spurs and twig cankers. Mummies are fruit that were infected the previous season, shriveled up and either remained on the tree or fell to the ground in the orchard. These mummies serve as the initial inoculum source in the subsequent spring.

Fungal spores develop on mummies left hanging in trees or other infected woody tissue in the spring when temperatures reach 55-77 degrees Fahrenheit. Wind and rain disseminate spores onto flowers where infection can occur. Although the fungus more readily infects open flowers, infection at the white bud stage is possible in optimal temperatures between 68-86 F during long periods of wet conditions of a minimum of five to 10 hours; more severe infections can occur if wet periods last for 24 hours or longer. The optimal temperature range for blossom blight development is 72-77 F, but temperatures between 68-71 F are also conducive for infection. During long wetting periods and when high inoculum levels are present, infection can occur at temperatures that are lower and higher than this optimal range.

Emily Pochubay, MSUE

Emily Pochubay, MSUE

Sporulating fungi of the American brown rot pathogen on June drop sweet cherry (above) and on a cluster of ripening sweet cherries (below).

Fungal spores (conidia) from overwintering mummies, cankers and blighted blossoms also infect fruit. Damaged fruit are particularly susceptible to infection when conditions favor this disease. A few hours of wet weather and temperatures between 68-77 F are optimal conditions for infection. During the preharvest period, infected fruit lesions produce conidia that can spread quickly causing outbreaks of fruit rot.

IPM steps for beginners

Unlike European brown rot (*Monolinia laxa*) that is favored by cool and wet conditions, warm and wet weather is ideal for American brown rot development. The risk for infection is directly related to the amount of overwintering inoculum. Typically, sustained relative humidity values of 90 percent or above for 24 hours or more following wet periods are associated with optimal infection events; infections are less likely if relative humidity drops below 60 percent for an extended period following rain.

The key to managing American brown rot is using well-timed fungicide applications when weather is expected to be ideal for disease development.

- ► Prune to remove mummies and cankers from trees before bloom.
- ► This disease is particularly concerning in years with heavy crop load or if fruit become damaged. Effective insect management will help to prevent rot development.
- ► Possible fungicide options for managing this disease include the sterol inhibitors and succinate dehydrogenase inhibitors. American brown rot is becoming resistant to sterol inhibitor fungicides (documented in Michigan). Therefore, in areas with fungicide resistance, alternative modes of action should be used.
- ► Review all fungicide labels and supplemental labels prior to application for additional information on permitted uses.


Stone Fruit IPM for Beginners

Developed by the Great Lakes Fruit Workers and funded by a working group grant from the North Central Integrated Pest Management Center


Chapter 7

Bacterial canker

Juliet Carroll, NYSAES, Cornell University

Bacterial canker

Hosts

Sweet and tart cherries are the main hosts, but can also occur on plums and prunes.

Time of concern

In late summer and fall, as leaves drop off the tree exposing leaf scars, the bacteria that cause this disease (*Pseudomonas syringae* pathovar *syringae* and *P.s.* pv. *mors-prunorum*) infects buds, in which they overwinter. In spring, infected buds may be dead and fail to grow. However, infected buds can remain viable. As these infected buds begin growing in spring, the young, emerging leaves and flowers may remain symptomless or may succumb to infections, which can be promoted by frosts, frequent rainfall, high humidity and cool temperatures. During spring and early summer, bacteria can gain entry into branches and scaffold limbs via pruning wounds, especially if pruning is done during cool, wet and rainy weather. Young, newly planted trees are at greatest risk of damage from bacterial canker infections. However, any age tree can become infected and show symptoms.

Symptoms, damage and pest cycle

Bacterial canker causes several types of symptoms, depending on the plant tissue infected and the plant's age. Dead buds and spurs fail to grow due to infections originating through leaf scars. Young shoots emerging from infected buds may develop dead areas that coalesce and blight the shoot. Blighted shoots may lead to colonization of shoots and cankers on young wood.

Cankers may also form on shoots under dead, infected buds and spurs or via pruning wounds. Often, but not always, gum is produced by the tree in response to cankers. Though not common, leaf spots can occur when bacteria invade leaves during rainy, cool and humid weather. On leaf spots, look for a shiny, varnish-coated appearance from bacterial exu-

J.E. Carroll, NYSAES, Cornell University

Damage to a sweet cherry tree from bacterial canker caused by *Psuedomonas syringae* pv. *mors-prunorum.* Trees were pruned shortly before a drenching rain.

J.E. Carroll, NYSAES, Cornell University

Bacterial canker infection caused by *Pseudomonas syringae* pv. *syringae* of a sweet cherry shoot following a late spring freeze event.

date that has dried on the leaf. Leaf spots may drop out leaving shot-hole symptoms. Damage is caused mostly by the cankers, which destroy shoots and limbs and by systemic infections that can kill trees.

The bacteria live on plant surfaces, such as buds, shoots and leaves. The pathogen is most abundant on plant surfaces during spring and fall when weather is rainy. The bacteria enter leaf scars when leaves drop in fall and from there travel into buds. In spring, infected buds can result in diseased, emerging shoots and cankers can develop under dead buds. Pruning and wounds from limb breaks, etc. that occur during wet weather can open the tree to infection from the bacteria growing on the surface of the plant.

IPM steps for beginners

Because the pathogens live on plant surfaces, most trees probably have latent infections. Therefore, avoid predisposing factors, which include freeze prone areas, sandy soils, poorly drained waterlogged soils or prolonged periods of drought.

The most important aspect of managing bacterial canker is to select and prepare an optimal site for growing cherries and provide them with best cultural practices.

Copper sprays are suggested at 20 and 80 percent leaf drop in fall and at late dormant in spring to reduce the bacterial populations on the trees. However, copper sprays will be ineffective if bacteria in your orchard are resistant to copper.

Prune cherries after harvest when weather is dry and no rain is forecast. Leave a 6-inch-long pruning stub to dead end the infection.

J.E. Carroll, NYSAES, Cornell University

Gummosis, often associated with bacterial canker infections of stone fruit trees, is a general host defense response to injury. Bacterial canker infections may occur without the presence of gummosis, particularly in trees of low vigor.

J.E. Carroll, NYSAES, Cornell University

Above, branch pruned in August after harvest showing little to no progression of bacterial canker down the stub. Below, a branch pruned in March showing progression of bacterial canker down the stub and into the uppermost young lateral.

J.E. Carroll, NYSAES, Cornell University


Stone Fruit IPM for Beginners

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Chapter 8

Bacterial spot

William Shane, Michigan State University Extension

Bacterial spot

A bacterial disease caused by Xanthomonas, bacterial spot is an important disease caused by *Xanthomonas arboricola* pv. *pruni* (XAP), formerly *Xanthomonas campestris* pv. *pruni*.

Hosts

Peach, nectarine, apricot and plum.

Time of concern

Leaf and green twig infection begins in early spring, plus fruit infections start after shuck split until pit hardening in early summer.

Damage, symptoms, disease cycle

Affected trees have fruit spots, leaf spots and twig cankers. Fruit symptoms include pitting, cracking, gumming and water-soaked tissue. Fruit infected by bacterial spot are more susceptible to other fruit diseases such as brown rot and rhizopus, as well as infestations by insects. Severe leaf spot infections can cause early defoliation. Severe defoliation can result in reduced fruit size and sunburn and cracking of fruit. Early defoliated trees can be less vigorous and more prone to winter damage. Bacterial spot lesions on fruit are darker than those of peach scab, which are greenish-brown, sometimes fuzzy and not pitted. Bacterial spot-infected leaves develop angular black lesions in the angles between two leaf veins, with some varieties developing yellow tissue around lesions and more resistant varieties having only black lesions.

The pathogen (XAP) overwinters in diseased twigs, which may develop a black tip symptom during spring green-up. The black tip symptoms are the result of small, somewhat inconspicuous, half-inch to 3-inch water-soaked, gummy spring cankers that girdle twigs causing tip dieback. Water from rain or dew wash bacteria from spring cankers to infect green tissue through natural openings such as stomata and hydathodes, resulting in small areas of water-soaked tissue. Older leaves develop more resistance to infection. The fruit are susceptible to infection beginning when they emerge from the shuck and become more

William Shane, MSU Extension

Bacterial spot infection on Japanese plums.

William Shane, MSU Extension

Fruit pitting due to early bacterial spot infection.

William Shane, MSU Extension

Black tip on peach twig due to bacterial spot infection the previous season.

resistant at pit hardening. Bacterial multiplication and spread is favored by wet and warm (65 F to 95 degrees Fahrenheit) conditions. Infection is favored by sandy sites and wind-blown sand.

IPM steps for beginners

On sandy, windy sites that are prone to bacterial spot, choose varieties with more disease resistance. Fresh market peach varieties with more resistance include Biscoe, Contender, Harrow Beauty, Harrow Diamond, Starfire, John Boy, Loring, Messina, Glenglo and PF9A-007. Moderate resistance peaches include Allstar, Canadian Harmony, Coral Star, PF25, PF15, PF17 and Redhaven. Peaches that are more susceptible include Suncrest, Elberta, Fayette, Flavorcrest and Halehaven. More resistant processing peaches (non-melting flesh) include Venture, Goldnine, Vulcan, Vinegold and Virgil. More susceptible processing peaches include Babygold 5 and Babygold 8. Japanese and pluot plums tend to be more susceptible than European plum varieties.

On sandy sites, suppress blowing sand with the use of sod strips between trees and use gravel or other dust-suppressing methods on nearby dirt roads. A windbreak on the windward side of your orchard can help reduce bacterial spot problems.

Chemical control is used by commercial growers with some success, but it takes multiple applications and is generally not practical for backyard gardeners. Compounds available for use on peaches and nectarine include copper or oxytetracycline (Mycoshield and Fireline). Oxytetracycline is generally considered the most effective bactericide and less prone than copper to cause damage to foliage. For the latest information on rates and timing, contact an Extension tree fruit educator.

Ready for more precision

Bacterial spot frequently occurs when leaves are congested with water due to environmental conditions such as high humidity and dew, alternating rainy and sunny warm weather, and sandy soils with fluctuating water content. Under such situations, bacterial spot lesions on leaves may have a water-soaked halo that can be seen when the leaf is backlit by sunlight.

Bacterial spot infections may show glistening appearance due to dried bacterial growth on the lesion surface. This is a sign the interior infection has been very active since the last rain.

William Shane, MSU Extension

Range of bacterial spot leaf symptoms, some with only necrotic spots, some with leaf tissue yellowing.

William Shane, MSU Extension

Extreme gumming of peach fruit due to early bacterial spot infection.


Stone Fruit IPM for Beginners

Developed by the Great Lakes Fruit Workers and funded by a working group grant from the North Central Integrated Pest Management Center


Chapter 9

Black knot

William Shane, Michigan State University Extension

Black knot

A fungal disease caused by *Apiosporina morbosa*, previously named *Dibotryon morbosum.*

Hosts

Plum, tart and wild cherry. Rarely on peach, nectarine and apricot. Additional cherry species susceptible to black knot are chokecherry (*Prunus virginiana*) and European bird cherry (*P. padus*). Other species of cherries like pin cherry (*P. pensylvanica*), sand cherry (*P. pumilla*), tart cherry (*P. cerasus*), Nanking cherry (*P. tomentosa*) and Western sand cherry (*P. var. besseyi*) are more tolerant.

Time of concern

Early bloom until new growth has slowed, usually mid-summer.

Damage, symptoms, disease cycle

Affected trees have irregular thick, black swellings 1 to 6 or more inches in length on twigs and branches, often very conspicuous. Limbs with severe infestations have poor growth and production. Severely affected trees can degenerate to a worthless condition in a few years.

The black knot pathogen overwinters in infected branches and galls in infected trees or pruned branches. During rain in spring, the knots release ascospores that are carried by wind and physical contact. Spores that land on susceptible young branches, twigs and leaf stems germinate and penetrate bark to establish infections. Infections are favored by frequent wetting periods and temperatures above 55 degrees Fahrenheit.

During the infection process, the fungus stimulates host tissue to swell, become olive colored and are noticeable by fall or next spring. After the first year, the infected areas are swollen, black, rough irregular galls. Galls produce and release ascospores starting approximately two years from infection. As the galls age, they are brown and start to disintegrate. Galls are often invaded by boring insects.

William Shane, MSUE

Black knot on wild plum in woods. Remove all infested trees within 500 feet of plum plantings.

William Shane, MSUE

This black knot on a plum has been invaded by a boring insect, as indicated by the lighter-brown frass in the center.

IPM steps for beginners

Avoid purchasing nursery stock with visible gall symptoms and watch trees closely in first year for new galls. Plum varieties with some resistance to this disease include Shiro, Santa Rosa, Methley, Early Italian, Fellenberg, Seneca, Damson, Blufree, NY9, Au Rosa and President. Very susceptible varieties include Stanley, Valor, Shopshire and Rosy Gage.

Effective black knot management requires cultural and chemical approaches. Cut out all knots, including those on nearby wild hosts, to reduce chances for future infections. Remove knots before bud break when knots begin to release spores. Make pruning cuts to include the knots plus another 5 to 8 inches of growth closer to the trunk to remove infected tissue not yet showing symptoms.

Promptly remove pruned branches with knots from the site and burn to eliminate these as a source of infection. Managing black knot in a site where the disease has been established is at least a two-year project to eliminate knots that emerge the following year.

Start chemical treatments early, approximately bud break/opening in spring as protectant sprays. The most important sprays are from early bloom to early June. Fungicides are applied at seven to 10-day intervals from green tip/tight cluster to about mid-June when the active shoot growth stops.

Products

(**Important:** Check product labels to make sure the product is labeled for the crop.)

- Chlorothalonil is available under various product names such as Daconil, Docket DF, Bravo, Chloronil and Echo. Chlorothalonil is an effective contact fungicide also useful for brown rot. Check the label as some regions restrict this product use later in the season.

- Fenbuconazole (Indar) is used by the commercial fruit industry. It is a systemic material also effective for brown rot. Rotate with other materials to help avoid chances for fungal resistance.

- Topsin M is relatively effective. Add captan to help reduce chances for developing resistance to the fungicide by the black knot pathogen.

- Captan is not real effective by itself for black knot. Caution: Captan applied after bloom under slow, drying conditions may cause leaf burn (shot-holes) and after shuck off can cause fruit spotting in Stanley and some other European and some Japanese plum varieties.

- Wettable sulfur and copper materials are only moderately effective for this disease.

Ready for more precision

Black knot can be confused with crown gall, a bacterial disease that will occasionally cause galls in branches of tree fruit. Surfaces of black knot tend to be darker and rougher than crown galls.

Regional susceptibility of tart cherries to black knot seems to differ greatly, with some areas such as Ontario having heavy infestations and others such as Michigan reporting little or no problems.

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McFadden-Smith, W., Northover, J., and Sears, W. 2000. Dynamics of ascospore release by Apiosporina morbosa from sour cherry black knots. Plant Dis. 84:45-48.


Stone Fruit IPM for Beginners

Developed by the Great Lakes Fruit Workers and funded by a working group grant from the North Central Integrated Pest Management Center


Chapter 10

Cherry leaf spot

Emily Pochubay, Michigan State University Extension

Cherry leaf spot

Blumeriella jaapii

Hosts

Tart cherry, sweet cherry

Time of concern

Late bloom through post-harvest

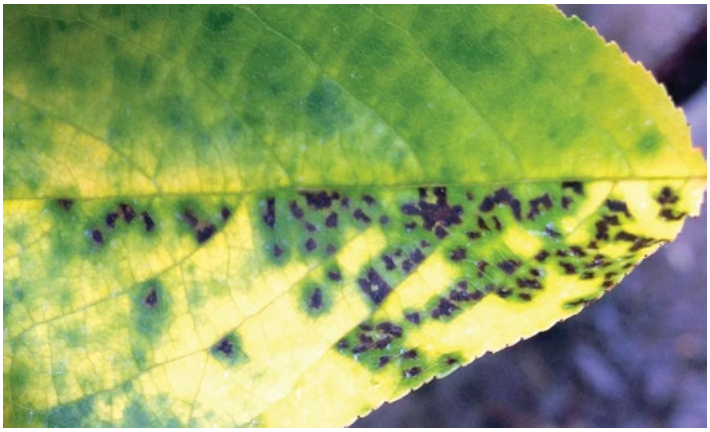
Damage, symptoms, disease cycle

Circular purple lesions that produce white spore masses indicate leaves are infected with leaf spot. Infected leaves turn yellow and drop prematurely. Significant infections early in the season can cause premature defoliation of entire trees resulting in yield reduction, a greater susceptibility to winter injury, tree health decline and premature tree death.

Cherry leaf spot is a fungal disease that infects leaves primarily on tart cherries and to a lesser extent on sweet cherries. The fungus overwinters on dropped leaves that were infected in the previous season. In the spring, the fungus forms fruiting bodies (apothecia) on infected leaves from the previous season that reside on the orchard floor. Ascospores, the life stage that infects leaf tissue, are released from asci on the apothecia during rainy periods. Ascospores that land on susceptible leaves germinate and infect through breathing pores or stomates on the leaves. Circular purple lesions appear where successful infection occurs and white masses of spores called conidia grow on the undersides of lesions. Rain and heavy dew spread the conidia to adjacent leaves and initiate secondary infections. This cycle continues through post-harvest until all leaves have fallen for the season.

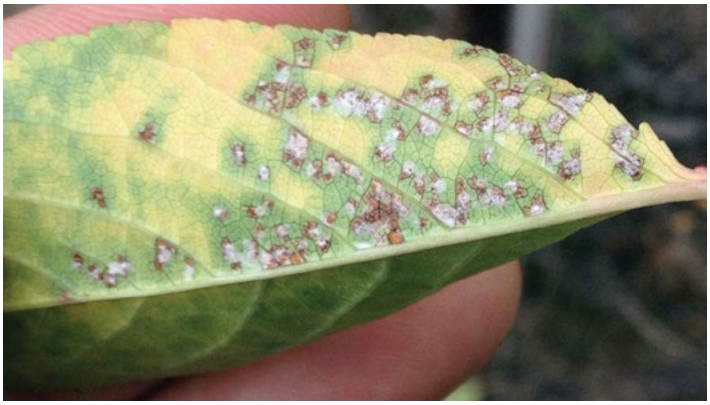
IPM steps for beginners

Preventing the onset of infection and disease progress throughout the season is key for managing cherry leaf spot. Once infection occurs, it can be very difficult to stop its spread as most fungicides will not eradicate the fungus.



Emily Pochubay, MSUE

Purple lesions and chlorosis caused by infection of the cherry leaf fungus on the top of a tart cherry leaf (above) and bottom (below).



Emily Pochubay, MSUE

- ▶ Delay the onset of infection through an effective management program in the current season to reduce inoculum load for next year's season.
- ▶ Prune to increase airflow in the canopy, which can improve fungicide coverage on foliage as well as reduce relative humidity in the canopy and drying time of leaves to minimize infection severity.
- ▶ Begin management programs when the first true leaves are expanded, which indicates that stomates are present, open and susceptible to infection. Leaf susceptibility often coincides with late bloom timing.
- ▶ Refer to MSU's current Fruit Management Guide for suggested fungicide options relative to growth stage; read and make applications in accordance with fungicide labels.

► Fungicides containing the active ingredient chlorothalonil are typically used early in the season. Using chlorothalonil products is not permitted after shuck split and before harvest.

Ready for more precision

Leaf spot infections are directly dependent on temperature and the duration of wet weather events (Figure of Eisensmith and Jones 1981 table). Therefore, monitoring weather and understanding when conditions are favorable for infection to occur is critical for effective management. The key to managing leaf spot is to prevent or delay the onset of infection for as long as possible. Currently available fungicides do not provide adequate leaf spot control after leaves are infected. These materials are protectant fungicides, meaning sprays should be applied prior to predicted periods of wet or humid weather that could trigger infections to prevent the onset of infection.

A cherry leaf spot disease model on Enviro- weather incorporates data on the disease's development in relation to past and current weather conditions to determine whether a particular location has experienced a possible infection period. Using real time data, the model assesses the severity of infection periods. This model helps growers assess the effectiveness of their management programs and decide when to apply or reapply a fungicide.

Emily Pochubay, MSUE

Chapter 11

European Brown Rot

Emily Pochubay, Michigan State University Extension

European brown rot

Monilinia laxa

Hosts

Tart cherry

Time of concern

White bud until petal fall

Damage, symptoms, disease cycle

European brown rot (*Monolinia laxa*) is a fungal disease that causes blossom blight and shoot and spur dieback of tart cherries (include blossom blight figure). In Michigan, the variety Balaton has traditionally been more susceptible than Montmorency. However, significant infections have been observed in Montmorency orchards with slow drying conditions such as those surrounded by windbreaks, in low spots and in areas where heavy fog settles. Unlike American brown rot that infects both blossoms and fruit, European brown rot-infected fruit have not been observed in the Great Lakes region.

Little is currently understood about the life cycle of European brown rot in the Great Lakes region. The fungus overwinters in infected spurs from the previous season and sporulates in the following spring before and during bloom. Blossom infection occurs during cool and wet conditions of temperatures from approximately 30 degrees Fahrenheit to the low 50s with rain or high relative humidity at the white bud stage before blossoms are open as well as during bloom. The fungus also invades shoots causing dieback and collapse of terminal ends and spurs along the infected branch. Infected spurs remain on the tree and serve as the source of inoculum for the next season.

IPM steps for beginners

Like many tree fruit diseases, the amount of overwintering European brown rot inoculum in specific orchards can play a significant role in the risk of infection under causal conditions.

► Visually scout orchards for infected spurs and shoots. Prune out infected branches to reduce the level of inoculum in the orchard.

Emily Pochubay, MSUE

Blossom blight and collapsing terminal ends caused by infection from the European brown rot fungus on tart cherries.

Emily Pochubay, MSUE

► Although weather plays a key role in whether or not blossoms will become infected, Balaton tart cherries should be treated for this fungus annually due to this variety's high susceptibility to the fungus.

- Applying an efficacious fungicide during susceptible blossom stages is the best option for management.
- One effective strategy is to make one application of a fungicide containing the active ingredient febuconacole at white bud followed by an additional application of this fungicide seven to 10 days later (during bloom) to prevent blossom blight.

Chapter 12

Peach leaf curl

William Shane, Michigan State University Extension

Peach leaf curl

Taphrina deformans (Berk.) Tul.

Hosts

Peach, nectarine

Time of concern

Pre-bud burst in spring and late fall.

Damage, symptoms, disease cycle

The pathogen infects young, undeveloped tissue of leaves and fruit. Infection occurs in spring under extended cool, wet conditions. Infections can occur at the first hint of swelling. Infected leaves curl and blister, leaving them severely deformed. Blisters may become discolored, ranging from white, light green, red to purple. Severely infected leaves eventually shrivel and fall to the ground.

Infected fruit either drop prematurely or remain on the tree and develop red blisters or wart-like deformities on their surfaces. The pathogen persists on the tree as a white, yeast-like growth easy to overlook.

IPM steps for beginners

Providing fungicide protection before buds start to swell in early spring is key for managing peach leaf curl. A limited number of peach varieties are immune to peach leaf curl, but most of these are not of sufficient quality for commercial fruit production. Peach varieties with showy (large, colorful) bloom tend to be more susceptible than non-showy types to peach leaf curl. However, fungicide coverage is needed for all varieties except those with immunity.

A fungicide spray can be applied in late fall after approximately 50 percent leaf fall or in early spring before any bud swell starts. The effectiveness of the fall spray depends on the coverage, type and concentration of fungicide used, and the amount of rainfall during winter. A fall and spring application of fungicide may be necessary to prevent peach leaf curl under spring conditions especially favorable for infection.

William shan, MSU Extension

Peach leaf curl symptoms on peach leaves. Affected leaves feel thick and rubbery and will eventually drop prematurely.

William Shane, MSU Extension

Peach leaf curl symptoms on peach leaves. Affected areas can range from white to purple.

Orchards severely affected by peach leaf curl may lose and regrow leaves. Such orchards may need more care—e.g., irrigation, sufficient nitrogen—to help the trees survive winter if severe, especially if the trees are in marginal health.

Effective fungicides include chlorothalonil, ziram and copper materials. See fungicide labels and university management guides for recommended rates. Reduced control of peach leaf curl with copper fungicides, reported from New Zealand, has not yet been reported in Michigan. Rotate fungicides, especially if copper fungicides are being used routinely for bacterial spot management.

Ready for more precision

Peach leaf curl infections occur in spring when wetting periods over 10 hours occur under cool conditions (46 to 53 degrees Fahrenheit) with rainfall greater than 0.5 inch. These rather specific conditions may not occur every spring, which explains why some years peach leaf curl does not show up on untreated trees.

Applying fungicide in fall is preferred over spring since poor spraying conditions in spring may prevent an application in time to prevent infection. During cool springs, infections can continue after bud swell if weather conditions are in the conducive range. Under such conditions, a fungicide application can be helpful even after the start of bud swell to prevent future infections.

Summer fungicide applications for brown rot control may provide some suppression of peach leaf curl for the following season. In low crop years or in young orchards when brown rot sprays are omitted, peach leaf curl problems can be worse in the following season.

The time between infection and first symptoms ranges from nine days under warm conditions to nearly a month in cool springs.

William Shane, MSU Extension

Peach fruit severely infected with peach leaf curl. Affected areas are generally dark red, raised, and very bumpy.

Chapter 13

Perennial canker

Juliet Carroll, NYSAES, Cornell University

Perennial canker

Hosts

Peach, sweet cherry, apricots and plums. It is most damaging on peaches.

Time of concern

During humid or wet weather, the fungi that cause perennial canker (*Leucocytospora cincta* and *Leucocytospora leucostoma*) produce tendrils of conidia, or asexual spores, in erumpent pycnidia that form in the dead bark on cankers. Dispersed by rain splash, the spores germinate and infect dead or injured tissue, such as leaf scars below buds; weak, shaded, senescent twigs; twigs killed by brown rot; pruning wounds; broken branches; or winter injury. The fungus expands into healthy tissue from the infection site, especially when trees are not actively growing or of poor vigor. Perennial canker infections and their spread are favored by wet and rainy weather.

Symptoms, damage and pest cycle

Perennial canker symptoms show up as brown, dark brown to black areas of dead bark on the tree. Most often the cankered areas will have a dead or dying twig or branch in their center, which was the initial site of the infection. Small, zonate cankers can also form on shoots under dead buds and spurs. Typical zonate, callous ridges may form, disfiguring the branch or trunk. These develop because in spring and fall the fungus can expand into healthy bark when the tree is not actively growing, but during summer the tree grows a ring of callous around the edge of the canker, the callous ridge is again colonized in fall and spring by the canker pathogen, and the cycle repeats. Often, but not always, gum is produced by the tree in response to canker infections. Cankers destroy shoots and limbs, weaken trees and shorten the productive lifespan of the tree in the orchard.

Leucocytospora cincta and *Leucocytospora leucostoma* produce numerous, erumpent pycnidia in dead bark on cankers. Inside the pycnidia, asexual

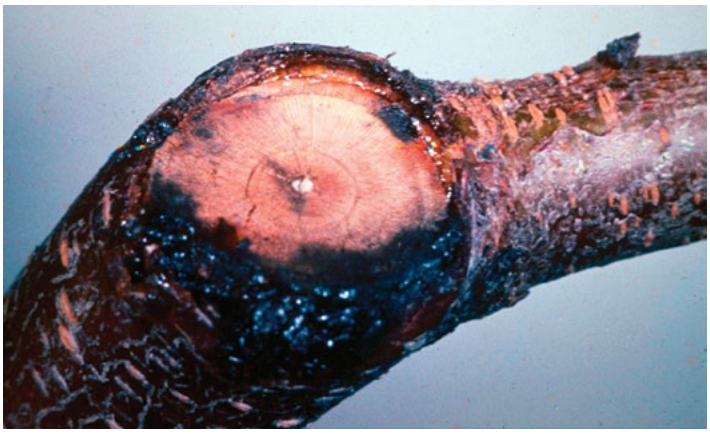
Wayne F. Wilcox, NYSAES, Cornell University.

Dark, sunken cankers expand along the limbs, producing large amounts of amber or dark brown gum at their edges. Often, dead twigs (in photograph) or pruning stubs can be seen at the center of such cankers.

Wayne F. Wilcox, NYSAES, Cornell University.

Canker margins grow callous that is colonized and killed back by the pathogen leading to their rough, zonate appearance.

spores or conidia are produced during humid and wet weather throughout the growing season. The conidia are extruded in tendrils that are splash-dispersed during rains. Spores require wet conditions to germinate and can infect only weakened, damaged or dead tissues. Pruning wounds and limb breaks that occur during wet weather can open the tree to infections, especially on newly planted trees and trees that lack vigor. The sexual spores or ascospores produced by *Leucostoma cincta* and *Leucostoma persoonii*, respectively, are sometimes found on cankers, but their role in the disease cycle is unclear.



Wayne F. Wilcox, NYSAES, Cornell University.

Gumming cankers can be seen at other common sites of infection, such as poorly healed pruning wounds.

IPM steps for beginners

The most important aspect of managing perennial canker is to select and prepare an optimal site for growing stone fruit and provide the orchard with best cultural practices. Because the pathogens can infect only weakened, damaged or dead tissues, avoid predisposing factors including winter injury, marginal sites, inadequate fertilization or prolonged periods of drought.

Do not establish young orchards near old orchards containing trees with perennial canker infections because the disease will spread to the newly planted trees, which are stressed from being transplanted and are at risk of infection due to pruning and heading cuts. Train trees to prevent narrow crotch angles between major scaffold limbs that are prone to breakage. Promote winter hardiness to prevent winter injury and apply a white latex paint to protect tree trunk and lower scaffolds from southwest injury during winter. Protect trees from damage by brown rot twig infections, oriental fruit moth terminal feeding, peach tree borers and rodent injury, all of which can create weak, damaged and dead tissue prone to perennial canker infection.

Cankered branches should be pruned out. Prune dead branches at least 4 inches (10 centimeters) below the canker margin; do not leave a stub, unless pruning sweet cherries at risk of bacterial canker infections. Cankers can be surgically excised when affecting less than half the diameter of the branch. Excised cankers should remove dead bark in an oval shape with about a 1-inch (2.5 centimeters) edge of healthy bark removed past the canker margin. Always prune trees when weather is dry and no rain is in the forecast, and when trees are actively growing and able to wall off the infection—after bloom. Remove prunings from the orchard and chip or burn them because perennial canker fungi can continue producing spores in the pruned branches left on the orchard floor.

Chapter 14

Phytophthora crown and root rot

Juliet Carroll, NYSAES, Cornell University

Phytophthora root and crown rot

Hosts

Tart and sweet cherry, peach, apricot. Plum is relatively resistant. Rootstock choice will affect susceptibility in the planting.

Time of concern

Spring and fall when soil conditions are saturated or wet. When soils are wet and cool or there is puddled water in the orchard, the lack of oxygen for roots makes the fruit more susceptible to infection. Wet conditions stimulate the pathogen to produce infective zoospores that actively swim towards the soil surface or towards host tissue to which they are chemically attracted. The zoospores germinate and infect susceptible roots, crowns or stems and the infection expands into healthy tissue from the infection site. Phytophthora infections and their spread are favored by wet and rainy weather. During the winter dormant season, the pathogen is not active and host susceptibility is low.

Symptoms, damage and pest cycle

Infected trees will appear unthrifty: internode lengths will be shorter; leaves will be small, few and off-color; and trees may wilt, collapse and die. Trees may limp along for a few years or collapse and die within one growing season. Phytophthora root and crown rot infections may be seen as reddish brown to brown areas of dead inner bark on roots, crowns and trunks. Sometimes this is visible without removing the outer bark. However, the discolored inner bark can be readily seen if a layer of bark is cut off to reveal the dead tissue underneath. Healthy inner bark will be white to greenish until it begins to oxidize. By comparison, Phytophthora-infected tissue will typically be reddish brown with a distinct border between diseased and healthy tissue. Infections may be impossible to detect without digging out the area around the tree crown to a depth of 6-12 inches (12-30 centimeters) and examining the rootstock for the typical reddish brown, discolored inner bark.

Wayne F. Wilcox, NYSAES, Cornell University.

Diseased trees will most likely be found in heavy, wet soils or sections of the orchard where water collects or is slow to drain (healthy tree in foreground).

Wayne F. Wilcox, NYSAES, Cornell University.

A diagnostic reddish brown discoloration of inner bark can be seen by removing several inches of soil around the base of declining trees and cutting away the outer bark layer on the exposed crowns. The knife shows the level of the soil surface before digging down to expose the diseased crown.

Because zoospores are motile, they are able to swim in films of water or be splashed onto the aboveground portions of the tree. Scion infection can occur in this way without rootstock infection in trees with resistant rootstocks and highly susceptible scions.

There are 10 or more *Phytophthora* species that can cause Phytophthora root and crown rot. This group of plant pathogens, the Oomycetes, produce dormant oospores (sexual) and chlamydospores (asexual) to survive unfavorable conditions in soil or in dead plant tissues or they survive as actively growing hyphal strands along the leading edge of infections. The dormant, resting spores or the hyphal strands can give rise to sporangia when soils are moist, wet or puddled. Sporangia fill with zoospores and expel them into the water-saturated environment. The zoospores actively swim to the soil surface or root tissues to disperse and cause infections.

The pathogen is inactive during winter. Water run-off, eroding soil, contaminated soil on boots, tractors and other equipment, and contaminated planting stock can all aid in spreading Phytophthora.

IPM steps for beginners

The most important step in managing Phytophthora root and crown rot is to provide the orchard with optimal soil drainage for growing stone fruit. Avoid sites with heavy, poorly drained soils or those that are subject to flooding. Improve marginal sites by using drainage tiles, diversion ditches or ripping underlying hard pans before planting. Planting tree rows on a raised ridge or berm helps by placing roots above the saturated soil zone where zoospores production and dispersal is favored.

Select rootstocks and scions with some degree of resistance to Phytophthora. Research the rootstock choices available for tart cherry, sweet cherry, peach and apricot cultivars being planted and match the rootstock to the site's risk for Phytophthora. Keep records of the rootstocks used and where they are planted in the orchard.

Place irrigation emitters so the emitted water doesn't directly spray or drench the tree trunk and crown. Avoid over-irrigation by using an irrigation model that will calculate the optimum amount of water to deliver for the soil type in the orchard.

Fungicides are registered to manage Phytophthora in tree fruit. However, trees showing severe symptoms of Phytophthora root and crown rot rarely recover when treated. Treatments prove effective mainly on trees without obvious, severe symptoms. Therefore, have Phytophthora root and crown rot confirmed in the orchard before undertaking the expense of treating the orchard to protect healthy or asymptomatic trees from infection.

Chapter 15

Post-harvest rots

William Shane, Michigan State University Extension

Post-Harvest Rots – Rhizopus, Alternaria and Sour Rots

Hosts

Peached, nectarines, apricots, plums and cherries.

Time of concern

Pre-harvest to storage.

Damage, symptoms, disease cycle

In addition to brown rot, several other fruit rot disorders can show up in storage. Rhizopus rot caused by the fungus *Rhizopus stolonifera* is responsible for overripe fruit rot in the orchard and can ruin fruit in storage. It is more commonly reported on peach and nectarine, but also occasionally on plum, cherry and apricot. Fruit infected by *R. stolonifera* develop a soft watery rot and "slip skin" due to the pectin enzyme activity of the pathogen. Infected fruit develop abundant white fungal growth followed by the massive production of black spores. *R. stolonifera* is common in orchards and can infect fruit through wounds. Fruit contaminated or infected with *R. stolonifera* can infect other fruit in storage.

Alternaria rot, caused by the fungus *Alternaria alternata*, is more common on fruit of sweet cherries and apricots than on other stone fruit. It is primarily a problem in cold storage, but can be seen on overripe or injured fruit in the orchard. *A. alternata* produces dark green to black growth on infected host material. The rot tends to be more superficial, darker and more compact than *Rhizopus*. *A. alternata* is a common contaminant in orchards and packing sheds.

Sour rot, caused by the fungus *Geotrichum candidum*, is an occasional post-harvest problem for peach and nectarine. Like Rhizopus rot, *G. candidum* is characterized by fine white mycelia, watery, soft fruit rot with some skin slippage. Sour rot has a distinctive vinegar smell, and does not develop the abundant white mycelium and black spore masses seen from *Rhizopus*.

William Shane, MSU Extension

Peach with Rhizopus peach rot showing loose skin.

William Shane, MSU Extension

Peach with Rhizopus peach rot showing abundant black sporulation.

IPM steps for beginners

Orchard, harvest and post-harvest sanitation and proper refrigeration conditions are important for managing these rot organisms. These three fungal pathogens and other less common fruit rots such as anthracnose (*Colletotrichum*) and gray mold (*Botrytis cinerea*) are favored by wounds, moisture and warm conditions. Fruit harvested mature and held at room temperature are prone to rot by these fungi.

- ► Avoid injury to fruit by insects during the growing season.
- ► Use fungicides effective against rot organisms during bloom and as fruit color near harvest.
- ► Avoid picking infected fruit during harvest.
- ► Maintain clean harvesting, packing and storage conditions.
- ► Cool fruit promptly following harvest, ideally below 40 degrees Fahrenheit, and consider pre- or post-harvest fungicide treatment and using treated water in packing operations.

William Shane, MSU Extension

Peach showing sour rot infection.

William Shane, MSU Extension

Sweet cherry fruit with alternaria rot symptoms.

Chapter 16

Powdery mildew

Emily Pochubay, Michigan State University Extension

Powdery mildew

There are multiple genera and species.

Hosts

Apricot, nectarine, peach, plum, sweet and tart cherry.

Time of concern

For crops affected by foliage infection, infection can occur from shuck fall until shoots stop growing. For peach, nectarine and apricot, fruit infection can occur from shuck fall to pit hardening.

Damage, symptoms and disease cycle

Powdery mildew refers to a complex of fungal species that infect apricots, nectarines, peaches, plums, sweet cherries and tart cherries. These fungi can infect foliage and fruit of susceptible stone fruits. Some of these stone fruits are susceptible to multiple powdery mildew species and multiple species may be present at the same time on these crops. Furthermore, whether foliage or fruit are susceptible to certain powdery mildew species is crop-specific.

Early symptoms of powdery mildew on green tissue of cherry manifest as a network of fine, white, thread-like mycelia. In more advanced infections, colonies of conidia may be present. Deformed or puckered leaves, chlorosis and abscission of leaves may occur if infection on the leaves is severe. On peaches and nectarines, the most common symptom is a superficial circular white fruit spot appearing two to four weeks after shuck fall. Under conducive weather, spots or lesions can expand to cover much of the fruit. The white color is later replaced by a brown to orange colored russet—a somewhat smooth spot that is more conspicuous on non-blush areas of the fruit.

Affected areas on peach fruit generally have less fuzz. Some species of powdery mildew also cause only foliage symptoms on peach, similar to cherry. Infection by powdery mildew on apricot are less common and can consist of foliage symptoms similar to cherries and fruit spot symptoms similar to peaches and nectarines.

William Shane, MSUE

Peach leaf tissue infected with powdery mildew.

William Shane, MSUE

Peach fruit infected with powdery mildew.

Various life stages of powdery mildew fungi overwinter on infected leaves and in bark and bud crevices. In cherries, cleistothecia (chasmothecia) overwinter in these locations, while in peaches, powdery mildew primarily overwinter as mycelia in inner bud scales. Free water such as rain or heavy dew in the spring triggers the release of ascospores that can initiate primary infection on leaves and developing fruit, depending on mildew species and crop. Symptoms are often first visible in cherries on the leaves of inner canopy trunk sprouts, branches near main scaffolds and those positioned above tree crotches.

Tissues infected during the primary cycle serve as the inoculum source of secondary infections throughout the season. Alternative hosts may also play an important role. For example, a species of powdery mildew that infects apples can also infect some peach varieties and is known as rusty spot. Additionally, another species of powdery mildew that causes foliage symptoms on peaches can also infect roses.

IPM steps for beginners

Powdery mildew is effectively managed through using well-timed fungicide applications or using resistant or more tolerant varieties. In susceptible varieties, the key to managing this disease is to prevent the fungus from getting a foothold by beginning management programs before symptoms appear and at specific crop stages. Furthermore, select a fungicide that targets multiple diseases that may be a concern at specific timings.

- For example, in cherries, powdery mildew management often begins with an application of an efficacious fungicide at first cover timing. Commercial growers will often use a fungicide that targets cherry leaf spot and powdery mildew or use a tank-mix of chemistries to target diseases at this timing.
- Managing rusty spot on peaches and nectarines focuses on sprays from shuck split to pit hardening. Most peach and nectarine varieties are resistant to rusty spot. However, peaches significantly susceptible to rusty spot (John Boy, Loring, Bounty, Laurol, Redskin, Raritan Rose, Victoria, Jerseyglo, Autumnglo and Suncrest) require fungicide treatment directed at this disease. In general, rusty spot symptoms tend to be worse on peach varieties with showy (large) bloom.
- Powdery mildew tends to be worse in low areas with higher relative humidity, so it is a good strategy to put varieties with greater susceptibility in higher areas where the humidity tends to be lower and away from alternative hosts that may be harboring the pathogen.

William Shane, MSUE

Peach fruit infected with a species of powdery mildew commonly referred to as rusty spot.

Emily Pochubay, MSUE

Advanced symptoms of powdery mildew growth on tart cherry leaves.

Chapter 17

Scab in peaches, nectarines and apricots

William Shane, Michigan State University Extension

Scab

Fusicladium carpophilum

Hosts

Peach, nectarine and apricot.

Time of concern

From shuck split to 1 month before harvest.

Symptoms and damage

Scab is a significant disease on peaches and nectarines, but generally of minor concern on plums and apricots. Slightly raised, circular lesions from 3 to 7 millimeters in diameter on new green twigs appear in spring to early summer. Twig lesion color progresses from green to reddish brown and eventually dark brown, usually more conspicuous the year following infection. Leaf symptoms are most common on the underside, are less conspicuous than twig and fruit spots but also start as small, greenish spots, becoming dark greenish brown or black.

The most obvious symptoms are fruit spots starting as small, circular, velvety-green and brown lesions that darken to dark green and reach 2-3 millimeters in diameter, sometimes with a yellowish halo. Halos are more common on blush (red) areas of the fruit. Fruit spots tend to be clustered on the upper, usually stem end, and may cause skin cracking as fruit expand.

Fruit with spots and skin cracks tend to have less shelf life and are more prone to fruit rots. Scab lesions on fruit can be confused with bacterial spot, however bacterial spot lesions tend to be more pitted than scab lesions, which tend to be more superficial.

Pest cycle

Scab survives winter months as mycelia (fungal strands) in twig lesions and thick walled fungal strands (chlamydospores) on bark. Spores produced in the lesions in spring and early summer are splashed and blown to new twig growth and fruit.

William Shane, MSU Extension

Peach scab lesions are fuzzy, circular, olive-brown and generally do not indent or pit the skin and flesh like bacterial spot.

William Shane, MSU Extension

Although twig infection can occur before bloom in peaches, most twig growth and infection occurs approximately two weeks after shuck split. Fruit are not susceptible until they emerge from the shuck and there is some evidence that fruit become more susceptible as they lose hair. Symptom expression following infection is slow, requiring 25 or more days for twigs and leaves, and at least 40 days for fruit.

Infected twigs provide spores for infection during the following year, but generally no longer.

Monitoring weather and preventing infection

Spore production and infection are favored by high relative humidity, rain and mist, and temperatures in the 60 to 85 degrees Fahrenheit range.

All peaches and nectarines are susceptible to scab, although some varieties are somewhat more susceptible than others. Manage scab by using effective fungicides beginning about shuck split when fruit are exposed to scab spores. At this time, new twigs are large enough to be a significant target, and spore production by overwintering twigs is at the peak.

Routine fungicides used for brown rot management are generally sufficient for scab control, with the exception of DMI fungicides such as Indar and Quash. Scab can get established in orchards where spray coverage has been poor, requiring more diligence next year to protect fruit and new twig growth.

Presumably, fewer applications for scab are needed in dry years. However, forecasts are not accurate enough to guide fungicide sprays, and fungicides for scab are generally protectants and require application before infection takes place.

William Shane, MSU Extension

An apricot with scab.

IPM steps for beginners

- ► Provide effective fungicide coverage for approximately four weeks following shuck split to prevent scab lesions on fruit and establishment of scab twig cankers.
- ► The most critical sprays are those at shuck split and approximately 10 days later. Infections occurring within four weeks of harvest generally do not result in visible lesions.
- ► Monitor for scab symptoms on twigs and fruit to gauge the effectiveness of spray programs and the need for better fungicide coverage.
- ► Prune to promote air movement to discourage fungal activity and good spray penetration for fungicide applications.
- ► Refer to Michigan State University's current "Fruit Management Guide" for suggested fungicide options relative to growth stage; read and make applications in accordance with fungicide labels.

Chapter 18

X-disease in peaches

William Shane, Michigan State University Extension

X-disease pathogen

Candidatus Phytoplasma pruni.

Hosts

Sweet and tart cherry, peach and nectarine. Alternate hosts include clovers, dandelion, chokecherry, almond and several wild plum and cherry species.

Time of concern

Management is focused on removing infected hosts before leafhopper spread can occur.

Symptoms and damage

Peach and nectarine leaves develop red, necrotic areas that drop out, leaving a shot-hole effect and tattered leaves. Defoliation at the base of a shoot gives a poodle tail or pompom appearance. Fruit on infected branches is smaller, lacks flavor often with a bitter taste and may drop before ripening.

Usually by the third year after infection, most branches will show symptoms. Young trees die within one to two years after the first symptoms appear. Older trees gradually decline in vigor.

Sweet and tart cherries infected with X-disease phytoplasma show stunted growth, enlarged stipules and immature, small, poorly colored fruit. Infected cherry trees on mahaleb rootstock decline quickly, whereas those on mazzard rootstock may persist for many years.

Pest cycle

Chokecherry is an important natural reservoir of peach X-disease phytoplasma in eastern USA. Infected sweet and sour cherries, especially on mazzard rootstock, can be sources of X-disease, although chokecherry is often the principal reservoir.

Other reservoirs of X-disease include weeds such as clover and dandelion.

Peaches and nectarines, although severely affected by the pathogen, are poor hosts for further disease

William Shane, MSU Extension

Sweet cherry leaf with enlarged leaf-like stipules at the base of the petiole due to X-disease.

William Shane, MSU Extension

Peach leaf with wine-red splotches typical of X-disease symptoms.

spread. X-disease spreads in mid-summer to late October when specific leafhopper species spread the pathogen from infected to healthy hosts.

Monitoring weather and preventing infection

Weather monitoring does not play a role in X-disease management. X-disease spread is favored by mild temperatures favoring leafhopper multiplication and build-up of the pathogen in infected trees. However, this provides no help in management because no chemical control is labeled that will effectively protect trees from infection. Insecticide coverage may help to suppress leafhopper movement, but this is not a reliable method of X-disease management.

IPM steps for beginners

For eastern North America, managing X-disease is focused on avoiding and eradicating infected plants.

- ► Scout for and remove chokecherry in a 200-meter perimeter of susceptible fruit trees. Infected chokecherry develops early, bright red fall colors and may die back to the ground, but may sprout again in subsequent years.
- ► Carefully monitor sweet and tart cherries for symptoms of X-disease and promptly remove trees if detected.
- ► Buy tree stock from nurseries with certification programs and avoid propagating from plants not protected from viruses and phytoplasma.

William Shane, MSU Extension

Defoliation of basal leaves on shoots due to X-disease gives the branches a pompom or poodle-tail appearance.

Chapter 19

American plum borer

Julianna Wilson, Michigan State University, Department of Entomology

American plum borer

Euzophera semifuneralis (Walker)

Hosts

Mostly attacks plums and cherries, but can be a pest of peach and nectarine in most fruit-growing states and provinces in eastern North America. Infestation of healthy, non-wounded tissue is rare.

Time of concern

Two generations or major flight periods are common in its northern range. First-brood adults emerge in early May into June with peak emergence in mid-May at the white bud stage. The second flight begins in early July and extends through mid-September, coinciding with the mechanical harvest of cherries.

Damage, symptoms and pest cycle

The adult is a light grayish brown moth with reddish brown forewings marked by wavy black and brown vertical bands about two-thirds the distance from the base.

NYAES

The larva ranges in color from grayish green to grayish purple, with a yellow to brown head capsule, cervical shield and anal plate.

NRAES-75

Larvae feed in the cambium layer of the trunk or scaffolds, which they can access only through openings created by mechanical damage, disease, sunscald, winter injury, etc. They also infest black knot in plums. Because they feed horizontally, girdling can eventually occur; drought conditions intensify feeding effects.

NRAES-75

Visible damage by larvae.

IPM steps for beginners

Examine the trunk area up to 3 feet from the ground for frass and fresh gumming with frass. Use pheromone traps to monitor species presence and flight activity starting at the end of April, replacing lures before the summer generation emerges at the end of June. An average of six adults per trap per week indicates a potential problem.

Minimize trunk damage caused by mechanical harvesting and cankers. Where populations of the pest are high, apply coarse insecticide sprays directly to the tree trunk shortly after petal fall and again, if necessary, in midsummer.

Acknowledgements: This information was adapted with permission from “Tree Fruit Field Guide,” NRAES, Cornell University.


Stone Fruit IPM for Beginners

Developed by the Great Lakes Fruit Workers and funded by a working group grant from the North Central Integrated Pest Management Center


Chapter 20

Aphids

Julianna Wilson, Michigan State University, Department of Entomology

Aphids

Black cherry aphid, *Myzus cerasi* (Fabr.)

Green peach aphid, *Myzus persicae* (Sulzer)

Aphids are small, sap-feeding insects that can multiply rapidly but are considered to be occasional pests of stone fruit. They are more likely to be a problem when pyrethroids or other broad spectrum insecticides used to control other orchard pests have inadvertently knocked out natural predators. Scout for the insects on susceptible plant tissue where they have been a problem in the past. The two most common aphids likely to be found in stone fruit orchards are described below.

MAOMG

Black cherry aphid, *Myzus cerasi* (Fabr.)

NYSAES

Hosts

Sweet cherries

Time of concern

In spring, on new foliar growth.

Damage, symptoms and pest cycle

This aphid attacks mainly cherries, particularly sweet cherries. Adults and nymphs establish colonies on new foliar growth in the spring, usually on the undersides of the leaves of growing shoots. They feed by sucking sap out of the leaves and tender shoots, causing a curling and stunting of the leaves. Heavy infestations reduce crop quantity and quality on mature trees, limit fruit set the following year and may kill young trees. Honeydew secreted by aphids promotes a black sooty mold on the fruit and foliage.

Adults and nymphs are shiny, black, soft-bodied insects; adults may or may not have wings. Nymphs are smaller but generally similar in appearance to the adults.

IPM steps for beginners

Protect natural predators. Monitor colonies on growing shoots; applying selective insecticides may occasionally be necessary.

NYSAES

Green peach aphid, *Myzus persicae* (Sulzer)

Hosts

All stone fruit, but especially peaches.

Time of concern

Spring through early fruit development.

Damage, symptoms and pest cycle

This pest attacks peach and all stone fruit crops and is the main vector of plum pox virus (reported from Ontario, Pennsylvania and Nova Scotia). Adults and nymphs suck the sap from leaf undersides, causing curling and yellowing of foliage. Flowers and fruits may also be fed upon, resulting in distortion and discoloration.

Whitney Cranshaw, Colorado State University, Bugwood.org

These smooth-looking, pear-shaped insects have long antennae and a pair of cornicles extending from the posterior end of the body. Wingless adults and nymphs are yellowish green, with three darker green lines on the abdomen.

Eugene E. Nelson, Bugwood.org

Damage to plum leaves caused by infestation with green peach aphids.

Scott Bauer, USDA Agricultural Research Service, Bugwood.org

Winged adults are similar in color, but with a dark head and thorax.

NYSAES

Green peach aphid on a nectarine.

IPM steps for beginners

Protect natural predators. A dormant oil application can help suppress overwintering egg hatch. Motile forms can be treated with an insecticide as they appear in the spring.

Chapter 21

Cherry fruit fly and black cherry fruit fly

Arthur Agnello, Cornell University

Cherry fruit fly and black cherry fruit fly

Rhagoletis cingulata (Loew)

Rhagoletis fausta (Osten Sacken)

Hosts

Sweet and sour cherries are readily attacked by both species. The principal wild host of the cherry fruit fly is the black cherry, *Prunus serotina*. The black cherry fruit fly infests almost exclusively the smaller-fruited, native “bird cherry” or “fire cherry,” *P. pennsylvanica*.

Time of concern

Emergence begins in late May or early June when early sour cherry varieties begin turning red or when 950 degree-days above 4.4 degrees Celsius (40 degrees Fahrenheit) have accumulated after March 1. As a rule of thumb, black cherry fruit flies (Fig. 1) emerge at McIntosh apple petal fall and cherry fruit flies (Fig. 2) emerge seven days later.

Flies continue emerging for about one month, into early July. Peak emergence occurs in mid-June for black cherry fruit flies and late June for cherry fruit flies. Freshly emerged flies move actively about the foliage and feed on honeydew produced by aphids or other insects. After about one week, flies are sexually mature. Mating takes place on the fruit and egg laying begins.

Damage, symptoms and pest cycle

Both species attack cherries; the female fly pierces the fruit with her sharp ovipositor and inserts a single egg just below the skin, leaving a small scar on the surface (Fig. 3). Little damage results from the egg puncture itself, and the egg-laying scar can be inconspicuous. If the fruit is stung while still green, such as with late varieties, and before it has fully sized, a small dimple will form around the egg puncture (Fig. 2).

Infested fruit may initially appear sound and will not drop prematurely. Larval feeding in the fruit will separate the pit from the pulp and cause the pulp to turn brown (Fig. 4). Sometimes the skin shrivels over the injured area. The young larva feeds next to the pit and matures in two to three weeks. When the fruit is ripe or overripe, the full-grown larva bores through the skin (Fig. 5) and drops to the ground to pupate (Fig. 6).

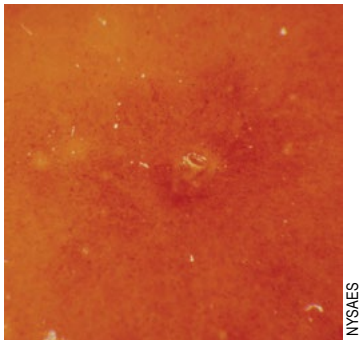
Cherry fruit flies and black

NYSAES

Fig. 1. Black cherry fruit fly adult.

NYSAES

Fig. 2. Cherry fruit fly adult.



NYSAES

Fig. 3. Oviposition scar.

cherry fruit flies have a similar seasonal biology: only one generation a year throughout their geographic ranges. Except for the adults, the eggs, larvae and puparia of the two species look alike.

Brown rot (*Monilinia* sp.) can start in wormy fruit (Fig. 5) and spread to other cherries. Late cherry varieties are usually more heavily infested than early varieties.

IPM steps for beginners


NYSAES

Fig. 5. Ripe cherries showing cherry fruit fly exit holes.

The date of first emergence in an area can be determined by collecting infested cherries, caging them on the ground under several trees (preferably in the south quadrant) and observing fly emergence in the cages the following spring. A more convenient method for monitoring cherry fruit fly activity is using baited fluorescent-yellow sticky boards. These traps attract cherry fruit flies, black cherry fruit flies, apple maggots and many other flies. Cherry fruit flies and black cherry fruit flies can then be identified by their characteristic wing patterns (Figs. 7 and 8). Consult local recommendations for using these traps.

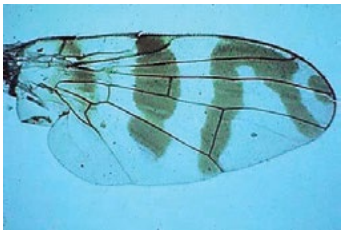

NYSAES

Fig. 7. Wing of cherry fruit fly showing characteristic markings.


NYSAES

Fig. 8. Wing of black cherry fruit fly showing characteristic markings.


NYSAES

Fig. 4. Cherry fruit fly larva feeding in fruit.


NYSAES

Fig. 6. Cherry fruit fly pupa.

Both species of cherry fruit flies build up in unsprayed, abandoned cherry trees or in wild *Prunus* tree hosts, and migrate from there to commercial orchards. Removing such sources of infestation will considerably reduce the cherry fruit fly threat in an area.

Cherries for commercial use must be free of maggots. To achieve such quality, apply insecticides to prevent female flies from laying eggs. The first spray should go on seven days after first fruit fly emergence, or when early varieties are beginning to show a tinge of color. The second is applied 10 days later, or when the Montmorency variety begins to color. Late varieties may require a third spray. Consult local cooperative Extension agents for advice on the most effective insecticides for cherry fruit fly and black cherry fruit fly control.

Stone Fruit IPM for Beginners
Developed by the Great Lakes Fruit Workers and funded by a working group grant from the North Central Integrated Pest Management Center

Chapter 22

Fruitworms and Leafrollers

Arthur Agnello, Cornell University

Fruitworms and leafrollers

Green fruitworm, *Orthosia hibisci* (Guenée)

Obliquebanded leafroller, *Choristoneura rosaceana* (Harris)

Hosts

Green fruitworm larvae feed on a variety of deciduous shade, forest and fruit trees and shrubs. **Obliquebanded leafroller** larvae feed on a wide range of plants; members of the rose family are their preferred hosts. **Obliquebanded leafroller** outbreaks have resulted in severe damage to apple, peach and pear fruit.

Time of concern

Green fruitworm adults (Fig. 1) are night fliers. Their flight closely parallels apple bud development. It begins at about green tip, peaks at tight cluster and is completed by the pink stage.

The spring flight of obliquebanded leafroller adults (Fig. 2) begins about three to four weeks after petal fall on apples, and continues for three to four weeks. In areas where obliquebanded leafroller has two generations, a second flight occurs from early August through early September.

NYSAES

Fig. 1. Green fruitworm adult.

NYSAES

Fig. 2. Obliquebanded leafroller adult.

Damage, symptoms and pest cycle

Green fruitworm have only one generation annually. Female green fruitworm moths begin egglaying on twigs and developing leaves when apples and peaches are in the half-inch green stage; green fruitworm larvae pass through six instars. Young larvae feed on new leaves and flower buds and can often be found inside a rolled leaf or bud cluster (Fig. 3).

NYSAES

Fig. 3. Young green fruitworm larva feeding on an apple bud cluster.

NYSAES

Fig. 4. Older green fruitworm larva feeding on developing apple.

Older larvae damage flower clusters during bloom and continue to feed on developing fruit and leaves for one to two weeks after petal fall (Fig. 4). They then drop to the ground, burrow 2 to 4 inches beneath the soil surface and pupate.

NYSAES

Fig. 5. Severe fruit damage to apple caused by green fruitworm feeding in the spring.

Most flower buds and blossoms damaged by green fruitworm larvae abort. Most fruit damaged just prior to and shortly after petal fall also drop prematurely. Some, however, remain at harvest and exhibit deep corky scars and indentations (Fig. 5). This injury is indistinguishable at harvest from that caused by overwintering obliquebanded leafroller larvae.

NYSAES

Fig. 6. Mature overwintered (spring) brood obliquebanded leafroller larva.

Obliquebanded leafroller may have one to two generations a year, depending on the locality. Overwintered (spring brood) obliquebanded larvae (Fig. 6) first feed on water sprouts and then move throughout the tree. Those feeding on developing flower buds do so before bloom and continue to consume floral parts throughout the blossom period. After petal fall, these larvae continue feeding on the developing fruit. Newly hatched larvae of the first summer brood move to and feed on tender growing terminals, water sprouts or developing fruit. As these larvae reach the third instar, they display an increasing propensity to damage fruit.

The first summer brood of larvae emerge in early July and complete development in late July or early August. Second brood larvae begin to emerge in mid-August and feed until they reach the third instar in fall, when they construct hibernation sites on twigs or bark and enter winter diapause. These overwintering larvae resume activity the following spring when the tree breaks dormancy and complete their development about three weeks after the apple blossom period.

The second brood larvae, which develop in late summer and fall, feed primarily on leaves until they enter diapause, although they may occasionally damage fruit. The most serious injury from overwintering obliquebanded leafroller larvae occurs just prior to and shortly after petal fall when the developing fruit is damaged. Many of these damaged fruits drop prematurely, but a small percentage remain on the tree, exhibiting deep corky scars and indentations at harvest (Fig. 7).

NYSAES

Fig. 7. Fruit damage to apples caused by obliquebanded leafroller larval feeding in the spring.

NYSAES

Fig. 8. Terminal damage to apple foliage caused by obliquebanded leafroller feeding.

Leaf injury by all broods is characterized by the larvae rolling leaves and feeding on surrounding foliage (Fig. 8).

The first summer brood larvae feed on the surface of developing fruit in late July and early August (Fig. 9). This injury is similar to that caused by several other species of leafrollers. Fruit damage caused by first summer brood obliquebanded leafroller larvae is usually more serious than spring feeding by overwintered larvae because more of the fruit injured later in the season remains on the tree at harvest.

NYSAES

Fig. 9. Fruit damage to apple caused by late season obliquebanded leafroller feeding.

IPM steps for beginners

Insecticides may be applied at petal fall, against the overwintering larvae of both of these classes of pests present at this time. This spray should adequately control green fruitworm. Obliquebanded leafroller adult flight can be monitored with pheromone traps; the first spray against the newly hatching summer brood larvae should be applied about three weeks after the first male moth is captured, and a subsequent spray should be applied 10 to 14 days later. Consult your local recommendations on using pheromone traps for this insect and the relative effectiveness of insecticides against newly hatched and large obliquebanded leafroller larvae.

Ready for more precision?

Apply protective sprays in orchards that have had a past history of severe obliquebanded leafroller fruit damage or if populations of overwintering larvae were high; the first spray should be timed to coincide with the first hatch of larvae at approximately 350 degree-day base 43 degrees Fahrenheit after biofix, followed by a second spray 10 to 14 days later. Refer to the NEWA Apple Insect Models website (newa.cornell.edu/index.php?page=apple-insects) for current information on the occurrence, development and management of this pest in your specific location.


Stone Fruit IPM for Beginners

Developed by the Great Lakes Fruit Workers and funded by a working group grant from the North Central Integrated Pest Management Center


Chapter 23

Lesser peachtree borer

Julianna Wilson, Michigan State University, Department of Entomology

Lesser peachtree borer

Synanthedon pictipes (Grote & Robinson)

Hosts

Lesser peachtree borer is a pest of all stone fruits, especially peach and cherry. It is found widespread in most fruit-growing states and provinces in eastern North America. With the prevalence of canker and winter injury in northern peach orchards, this species can be a major pest.

Time of concern

There are two generations per year in its northern range. First-generation adults begin to emerge around shuck split or shuck fall in peach. The flight of second brood adults generally begins in July and continues into September, overlapping with the adult activity of another important clear-wing moth, the peachtree borer (*S. exitiosa*).

Damage, symptoms and pest cycle

The adult is a clear-winged, metallic-blue, day-flying moth. Both males and females have two or more pale yellow narrow fringes of scales across the abdomen, making them appear wasp-like. Both males and females have pale yellow scales on the top of the head right behind the eyes and black scales between the antennae.

NRAES-75

The larva is white or cream-colored and hairless, with short legs and a yellowish brown to dark brown head.

NRAES-75

This pest attacks damaged areas of scaffold limbs of all stone fruits. Larvae feed on the inner layer of bark, killing the cambium and girdling the conductive tissue, which results in significant production loss in older orchards. Larvae normally gain entrance at areas that are already injured from Cytospora canker, winter injury, split limbs from heavy loads, or pruning or mechanical wounds. Their sites of infestation tend to be on the upper trunk or lower limbs and frequently cause a flow of gum containing frass.

NYAES

Since the lesser peachtree borer and the peachtree borer often occur together, it is important to note their major distinguishing features. Both male and female lesser peachtree borers can be mistaken for the male peachtree borers, except for the location of tufts of pale hair on their heads. In the lesser peachtree borer, they are found in back of the eyes. In the peachtree borer, the pale hairs will be between the antennae.

These two borers also can be distinguished by the fact that the lesser peachtree borer is earlier in the season, requires already injured trees, and infests higher up on the trunks and in the lower branches. The peachtree borer most often burrows under the bark at or near ground level and is only active later in the season.

IPM steps for beginners

Examine the bases of trees for frass or sawdust-like excrement in the exuded gum. Use pheromone traps to monitor species presence and flight activity. Pheromones used to monitor for lesser peachtree borer are species-specific. Mating disruption is an effective option in multi-acre plantings. Insecticide drenches or sprays to wounds on scaffold limbs can be applied at bud swell or in the summer.

Acknowledgements: This information was adapted with permission from “Tree Fruit Field Guide,” NRAES, Cornell University.

Chapter 24

Mites

Arthur Agnello, Cornell University

Mites

European red mite, *Panonychus ulmi* (Koch)

Twospotted spider mite, *Tetranychus urticae* (Koch)

Plum rust mite/peach silver mite, *Aculus fockeui* (Nalepa & Trouessart)

Hosts

European red mite is the most important mite species attacking all tree fruits in North America. Twospotted spider mite also attacks all deciduous fruit trees. The plum rust mite, also called the peach silver mite, attacks plums, peaches and cherries.

Time of concern

European red mite

European red mites (Fig. 1) overwinter as fertilized eggs (Fig. 2). Egg hatch is closely correlated with bud development and first occurs when apples buds are in the tight cluster stage; hatch is more than 50 percent complete at the pink stage, and virtually 100 percent complete by the end of bloom. The first summer eggs can, as a rule, be found at petal fall or at latest by fruit set. There are four to nine generations of European red mite a year, depending on the locality and length of the growing season. Environmental factors such as diminishing food supply, temperature and photoperiod trigger winter egg production from mid- to late August, but this may continue until late September.

NYSAES

Fig. 1. European red mite adult female.

NYSAES

Fig. 2. European red mite overwintering eggs.

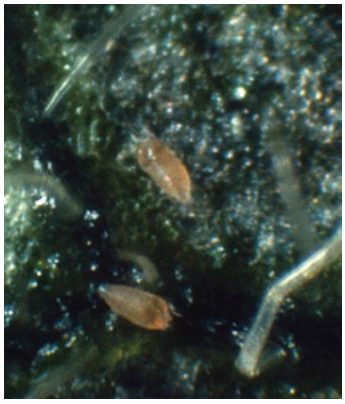
Twospotted spider mite

NYSAES

Fig. 3. Twospotted spider mite adult.

Twospotted spider mites (Fig. 3) overwinter as diapausing females in protected places on the tree or in the duff at the base. When weather warms in the spring, typically a few days or weeks before bloom, the females become active and seek out the newly emerged green tissues to feed. After the first generation in the spring, the generations begin to overlap, and all stages are usually present at the same time. The number of generations depends on the climate to some extent; this species can continue to reproduce if warm weather persists in the fall, or they can begin to overwinter well ahead of the cooler temperatures if food quality declines.

Plum rust mite



A. Howitt, MSU

Fig. 4. Plum rust mite adult.

Female mites (Fig. 4) overwinter chiefly in the cavities of dead or shrunken buds, and to some extent in crevices of twigs and bark; mites begin to leave the buds and migrate into the expanding foliage as the buds open, scattering over the foliage to feed for a few days. Peak populations usually occurs in late July, and overwintering females start being produced in August. Males, which do not overwinter, die in the fall.

Damage, symptoms and pest cycle

European red mite

Injury is caused by the feeding of all stages on the foliage. The lower leaf surface is preferred. Under

high populations, both surfaces are fed upon. The injury is caused by the piercing of the cell walls by the bristle-like mouthparts and the ingestion of their contents, including the chlorophyll. The injury results in off-color foliage that in severe cases becomes bronzed (Fig. 5, right), as compared to uninfested foliage (Fig. 5, left). The leaf efficiency and productivity is directly affected. Heavy mite feeding early in the season (late June and early July) not only can reduce tree growth and yield, but also drastically affect fruit bud formation, and thereby reduce yields the following year. Additionally, mite-injured leaves will not respond to growth regulators applied to delay harvest drop.

NYSAES

Fig. 5. European red mite foliar feeding damage.

Twospotted spider mite

All motile stages feed on tree foliage, with most of the feeding concentrated on the lower leaf surface. Mites have piercing-sucking mouthparts that penetrate the leaf cells and withdraw the contents, including chlorophyll. The injury caused (Fig. 6) is similar to that of European red mite; however, bronzing is more gray, and there is much more webbing present than occurs from similar populations of European red mite.

IRDA, Canada

Fig. 6. Twospotted spider mite foliar feeding damage on apple.

Plum rust mite

The mites live on the upper and lower surfaces of the leaves along the midribs. They feed extensively on only young foliage, so injury is confined chiefly to terminal growth. Though the mite is common on mature trees, particularly on water sprouts and terminal shoots, serious injury has been noticed particularly on nursery stock. Feeding causes the leaves to roll upward longitudinally and turn brown (Fig. 7). Symptoms may be present over the entire tree. Early injury to the leaf may cause dwarfing of the foliage and a brown or bronze scurfy condition on the lower leaf surface.

On plums, individual leaves may exhibit a condition known as “chlorotic fleck.” Symptoms of chlorotic fleck are more or less well-defined chlorotic areas (abnormally yellow plant tissue resulting from partial failure to develop chlorophyll) that range in size from mere spots to 1-2 millimeters in diameter. The number of flecks on a single leaf may vary from one to more than 50. If sufficiently numerous flecks are present, the leaf may become twisted. Severely infested shoots are rosetted, and many leaves do not expand to normal size. Symptoms may occur on the bark of plum shoots in the form of ovoid spots.

In cherries, partial defoliation will occur under severe infestations.

A. Howitt, MSU

Fig. 7. Plum rust mite foliar damage.

IPM steps for beginners

Mites are known as “induced pests”—they only reach outbreak conditions where biological control is disrupted (e.g., by pesticides used in commercial orchards); levels on unsprayed trees are usually

negligible. Mites have a number of insect predators, including small black lady beetles in the genus *Stethorus* and some predatory bugs, but by far the most successful spider mite biocontrol agents are predatory mites in the family Phytoseiidae, and to a lesser extent, Stigmaeidae. These species (e.g., *Galendromus occidentalis*, *Neoseiulus fallacis*, *Typhlodromus pyri*) live in close association with their prey, and in many cases have become tolerant of orchard pesticides. This allows them to continue providing biological control even in the presence of multiple pesticide inputs.

While biological control plays a significant role in spider mite management worldwide, controlling direct (fruit-feeding) pests may necessitate using disruptive chemicals in the orchard. A number of specific miticides are currently available, with activity either on the eggs (ovicides or ovicide/larvicides) or the adults. Ovicides typically work better early in the season, or when population densities are still low. High populations are better controlled with an adulticide (alone or in combination with an ovicide). European red mites can be readily controlled by thorough and timely acaricide applications. The most effective treatments are those applied after new growth has appeared but ahead of bloom. Seasonal control can often be obtained with a single petroleum oil spray directed against the overwintering eggs or the application of an acaricide toxic to the newly hatched forms. Against established populations in the summer, it is often necessary to make two applications 10-14 days apart. In cherries, plum rust mites often become a problem after harvest; if necessary, take chemical control measures after harvest to ensure tree vigor for the winter.

Spider mites have a long history of developing resistance to pesticides, therefore a program of resistance management should always be a primary concern when developing a chemical control program. Rotating materials with different modes of action, combined with using biological control whenever possible, should help prevent resistance from developing.

Chapter 25

Oriental fruit moth

Julianna Wilson, Michigan State University, Department of Entomology

Oriental fruit moth

Grapholita molesta (Busck)

Hosts

Peach is the main concern but it can attack all tree fruit.

Time of concern

April through peach harvest.

Damage, symptoms and pest cycle

Attacks all deciduous fruits, particularly peach and apple. On peach, larvae feed first on new terminal growth, tunneling toward the base of the shoot and causing the terminal to wilt and die back, also called "shoot flagging." This damage may be confused with that caused by periodical cicada oviposition, which can also cause terminal wilt. Young orchards are especially susceptible to this injury and if left unchecked, terminal feeding can lead to serious problems with tree architecture as new shoots emerge to replace the dead ones.

Later, broods attack and tunnel in the developing fruit, usually causing conspicuous entrance or exit holes covered with frass, while the larvae excavate cavities near the pit. Sometimes larvae enter through the stem or through a split in the fruit so that the fruit appears undamaged.

The adult is a small moth with dark gray mottled wings that lighten somewhat at the outer edges.

Oriental fruit moth adult.

Michael Haas, MSU Entomology

Michael Haas, MSU Entomology

Shoot death is a symptom easily seen from a distance.

Michael Haas, MSU Entomology

A wilted tip indicates a larva may be feeding inside.

Michael Haas, MSU Entomology

Cutting open the tip exposes the feeding larva.

William Shane, MSU Extension

Use a red or orange Delta trap for oriental fruit moth. Do not use a white trap as it will also attract bees.

The larva is dirty white to pinkish with a reddish brown head and an anal comb. The anal comb, found at the posterior end, may be seen by applying gentle pressure to the larvae while looking at it with a hand lens or under a microscope. The presence of the comb is what distinguishes oriental fruit moth larvae from early instar codling moth larvae, which they resemble.

IPM steps for beginners

This insect historically has been the major internal worm pest in commercial peaches. Monitor adults with pheromone traps and use a degree-day developmental model to time insecticide sprays. Place Delta style traps 4 to 6 feet from the ground in the outer edge of the canopy with the trap direction so that a moth flying around the tree has the openings at either end of the trap available for trap entry.

Select summer insecticide applications targeting other pests based on whether they are also effective against oriental fruit moth. Practice insecticide rotation with this pest as resistant populations are known to develop when rotation is ignored. Some areas within the state have had problems with oriental fruit moth resistance to pyrethroid insecticides.

Ready for more precision

Successful control of this pest has been achieved using mating disruption alone, especially in area-wide programs, or under heavy population pressure, in combination with insecticide sprays. Do not use mating disruption in newly planted or very young orchards as there is not enough canopy development to "hold" the pheromone in the orchard. For information on how to use mating disruption, see "Guide for Using Mating Disruption to Manage Oriental Fruit Moth in Michigan Tree Fruits."

Michael Haas, MSU Entomology

Evidence of fruit feeding on the exterior of a peach.

Michael Haas, MSU Entomology

Frass from the larva accumulates at the entry point.

Michael Haas, MSU Entomology

Larva feeding inside the fruit.

Chapter 26

Peachtree borer

Julianna Wilson, Michigan State University, Department of Entomology

Peachtree borer

Synanthedon exitiosa (Say)

Hosts

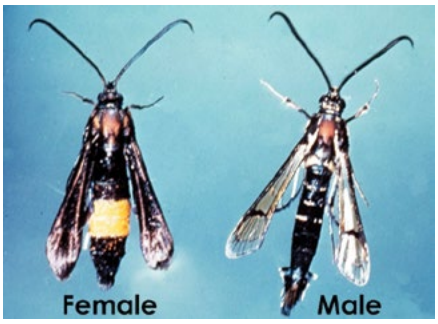
Peachtree borers attack all stone fruits, but can be a major pest of peach. They are found throughout most fruit-growing states and provinces in eastern North America.

Time of concern

In its northern range, there is only one generation per year. Adult emergence begins in early July, peaking in August and extending into September. Control programs for the peachtree borer in peach orchards must begin in the first year trees are planted and maintained throughout the life of the orchard.

Damage, symptoms and pest cycle

Adults are clear-wing, day-flying moths that may be mistaken for wasps. Their bodies are dark steel-blue with females having a wide band of bright orange scales on their abdomen and males having four narrow bands or fringes of white or yellow scales. Both sexes will have an amber sheen to their fringed wings and have a tuft of pale-colored hair between their antennae.



NRAES-75

Larvae are white or cream-colored and hairless with short legs and a yellowish brown to dark brown head.

NYAES

The larva burrows into the bark, usually near the soil surface, and feeds on the cambium and tunnels between the inner bark and the sapwood. Larvae normally attack the tree trunk between 7.5 cm (3 in) below ground to 25 cm (10 in) above ground. Larger roots Areas attacked often have masses of gum mixed with frass exuding from the bark. Young trees may be completely girdled and eventually die; older trees are debilitated and more susceptible to other insects or diseases.

NYAES

Since the peachtree borer and the lesser peachtree borer (*S. pictipes*) often occur together, it is important to note their major distinguishing features. The male peachtree borer can be mistaken for either male or female lesser peachtree borers, except for the location of tufts of pale hair on their heads. In the peachtree borer, the pale hairs will be between the antennae. In the lesser peachtree borer, they are found in back of the eyes.

These two borers also can be distinguished by the fact that the peachtree borer is active later in the season and most often burrows under bark at or near ground level. The lesser peachtree borer is active earlier in the season, requires already injured trees and infests higher up on the trunks and in lower branches.

IPM steps for beginners

Examine the bases of trees for frass or sawdust-like excrement in the exuded gum. Use pheromone traps to monitor species presence and flight activity. Pheromones used to monitor for peachtree borer are not species-specific and will attract other clear-wing moths including dogwood borer and lilac borer. The lesser peachtree borer has a species-specific pheromone and will not be attracted to the peachtree borer lure. Mating disruption is an effective option in multi-acre plantings; also, summer or post-harvest trunk sprays of contact insecticides can be applied.

Acknowledgements: This information was adapted with permission from “Tree Fruit Field Guide,” NRAES, Cornell University.


Stone Fruit IPM for Beginners

Developed by the Great Lakes Fruit Workers and funded by a working group grant from the North Central Integrated Pest Management Center


Chapter 27

Plum curculio

Julianna Wilson, Michigan State University, Department of Entomology

Plum curculio

Conotrachelus nenuphar (Herbst)

Hosts

All

Time of concern

Beginning shortly after petal fall.

Damage, symptoms and pest cycle

Attacks all deciduous tree fruits. The larvae bore into and create galleries in stone fruits. In August, the adults that will overwinter in the north, or those that will produce a second generation in the south, feed on fruits before seeking overwintering sites in leaf litter near the orchard. Some oviposition of this brood also results in larval fruit infestations in late summer.

The adult is mottled grayish black and brown. Its head is prolonged into a large but short snout that bears antennae. Each elytron has a series of humps with the second and third pairs separated by a clear transverse band.

Clemson Univ, USDA Coop Exten Slides, Bugwood.org

The white elliptical eggs are deposited under the skin of the fruit in a crescent-shaped slit. The whitish larva, with no functional legs, has a C-shaped body, an elliptical head and a brown thoracic shield.

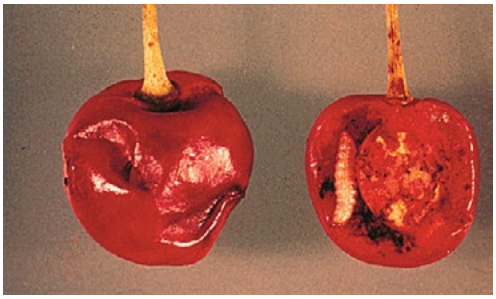
NYSAES

Krawczyk

Injury during peach shuck.

NYSAES

Injury on peach fruit.



NYSAES

A larva with damage in cherries.

IPM steps for beginners

Monitor regularly for fresh damage on fruit. Apply protective sprays during the egglaying period, starting at petal fall; a degree-day model can be used to predict the portion of the oviposition period during which insecticide protection would be required.

Chapter 28

Shothole borers

Arthur Agnello, Cornell University

Shothole borer

Scolytus rugulosus (Müller)

Hosts

The shothole borer is a pest of peach, cherry and plum and is found in all areas of the U.S. and Canada where stone fruits are grown.

Time of concern

In early June, the beetles appear on suitable trees and begin to excavate brood chambers between the bark and sapwood. Eggs deposited in the chambers hatch in three to four days and the grubs feed for up to 36 days, pupate and emerge as adults about 10 days later. There are two generations of this insect in the Northeast, with the second occurring around the end of July.

Damage, symptoms and pest cycle

J.R. Baker & S.B. Bambara, NCSU, Bugwood.org

This small, cylindrical dark beetle is normally found in dead or dying wood, but can be attracted to living trees (including peach, cherry and other stone fruits, as well as apple and crabapple) that are stressed or otherwise in an unhealthy condition. When populations are very numerous, healthy trees will be attacked. A tree that is moisture-stressed will often be attacked first, even before the tree gives any outward appearance of the problem.

The adult female chews a small hole, about the size of a pencil lead, through the bark and creates a burrow or brood chamber in the bark and wood. The holes are sometimes indicated by a small amount of sawdust or borings on the tree's bark. On peach, cherry and other stone fruits these holes are usually covered and sealed in by dried droplets of gum, which hang from twigs like tear drops. Individual eggs are laid into each burrow, after which the larvae hatch and burrow between the bark and sapwood at right angles from the brood chamber, creating grooves in the wood that resemble centipedes and are visible by removing the bark.

NYSAES

Shothole borer larval damage to plum.

This pest attacks the trunk, branches and twigs of suitable trees. All the inner bark and surface of the sapwood is quickly converted to dust by the primary wounds of the beetles and the more extensive burrowing of the numerous larvae.

M. Mailloux, MAPAQ, Québec

Holes and burrowing damage in tree limb.

When the insects are abundant, the fruit clusters wilt and the leaves associated with them become brown, resembling a fire blight infection. Woodpiles in the immediate area are often the source of infestations of emerging beetles, often in early June.

IPM steps for beginners

This is not an easy problem to solve and extensive damage of this type often kills the tree. Contacting the grubs with an insecticide is naturally very difficult, because they are concealed inside the wood in galleries during development.

A broad-spectrum insecticide applied when the adults are active is of value in controlling this insect. During winter, all badly diseased trees or branches in or near the orchard should be cut out and all prunings promptly burned. Infested firewood should be burned before spring following cutting. Trees that are in a backward, somewhat sickly condition should be given a heavy treatment in the spring with some strong nitrogenous fertilizer, applying the material to the soil surface above the tree roots.

Chapter 29

Spotted wing Drosophila

Julianna Wilson, Michigan State University, Department of Entomology

Spotted wing Drosophila

Drosophila suzukii (Matsumura)

Hosts

Sweet and tart cherries, plums.

Time of concern

In cherries, when fruit begins to color all the way until harvest. In plums, when fruit softens to 3.5 pounds of pressure through harvest.

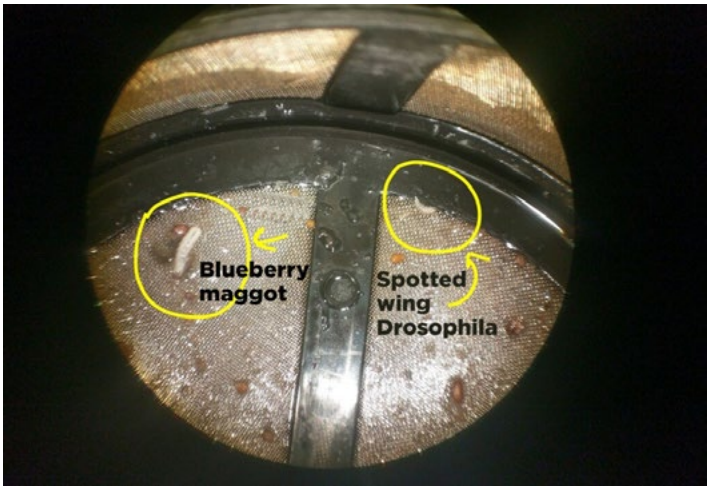
Damage, symptoms and pest cycle

Spotted wing Drosophila (SWD) attacks all thin-skinned fruit including wild hosts common in wooded areas in the Eastern U.S. In some areas, the timing of when fruit ripens and is harvested may not overlap with when SWD populations begin to surge. Where the summer population surge does overlap with susceptible fruit, this pest reproduces quickly, more like a disease in that each female is capable of laying over 300 eggs, which develop into new adults in as little as eight days. *Multiple overlapping generations within a season make this pest the most important pest in cherry production close to harvest.* A sugar or salt test can be used to find larvae, which feed inside the fruit.

Adult SWD have several key features to help distinguish them from other flies of their size. Females have a darkened, serrated (toothed) ovipositor that allows them to saw into intact, ripening fruit. Mature males have a dark spot on each wing near the margin and a dark ring of bristles on each foreleg.

Danielle Kirkpatrick, MSU Entomology

Adult on a cherry.



Steve Van Timmeren, MSU Entomology

SWD larva (circled on the right) compared with a blueberry maggot larva (circled on the left) in a coffee strainer after being extracted from blueberries using the salt test.

Danielle Kirkpatrick, MSU Entomology

Male adult fly.

Danielle Kirkpatrick, MSU Entomology

Female adult fly.

Karen Powers, Michigan State University

SWD larvae emerging from tart cherries held in a sugar solution.

IPM steps for beginners

Spotted wing Drosophila is such a new pest that we are learning new ways to combat it every season. What we do know is when the summer population surge overlaps with the ripening of susceptible crops, this pest is not easily controlled and there is a high potential for infested fruit at harvest, especially in cherries.

Baited traps are used to indicate when SWD are building up in a particular area, but multiple traps per farm are needed to be able to use the 10 percent threshold. This threshold is when 10 percent of traps in a given area are catching any SWD and fruit in that area are at a susceptible stage, then the crop must be protected.

It cannot be emphasized enough the tremendous capacity of this pest for reproducing rapidly. Controlling this pest requires a robust pest management program targeting adults before they have a chance to lay eggs in fruit. Similar to managing diseases like cherry leaf spot, excellent coverage with pesticide is required when adults are active. Use high spray volumes, apply full covers, tighten spray intervals and follow up with another insecticide after a rain event. Proper sprayer calibration is essential. Post-infestation treatments will not eradicate larvae, but use a sugar or salt test to determine whether your management program was effective.

Do not delay harvesting ripe fruit—the longer fruit stays on trees, the more likely it will be infested. Since plums color before they become vulnerable to SWD, one way to reduce the risk of infestation is to harvest plums before they soften since this crop can ripen off the tree. This may eliminate need for any insecticide treatments against this pest in plums.

Some preliminary work looking at canopy manipulation in tart cherries suggests opening up the canopy with pruning does three things to reduce infestation:

- ► Reduces humidity, making the canopy a less favorable place for flies to hang out.
- ► Improves insecticide penetration into the canopy for better coverage.
- ► Reduces the crop load, which can make harvesting faster.

Ready for more precision

For more information on monitoring, how to use the sugar test and managing SWD in cherries, see Michigan State University's "Managing Spotted Wing Drosophila in Michigan Cherry." For more on sprayer calibration, see the website sprayers101.com.

Rufus Isaacs, MSU Entomology

A trap used to attract and capture SWD adults. A commercially available pouch-style lure is suspended over a soap, borax and water drowning solution.

Chapter 30

Stink bugs

Julianna Wilson, Michigan State University, Department of Entomology

Stink bugs

While native stink bugs are only occasionally a pest in stone fruit or they are beneficial predators of other insects, the non-native brown marmorated stink bug can be a serious pest in peach and nectarine orchards. It has become an important late-season pest for growers in Mid-Atlantic states and is emerging as an important pest in fruit production areas elsewhere.

Brown marmorated stink bug

Halyomorpha halys (Ståhl)

Hosts

Peaches and nectarines mainly, but will attack other stone fruit.

Time of concern

As fruit begin to develop through harvest.

Damage, symptoms and pest cycle

Brown marmorated stink bugs move around during the season among different habitats, coming out of woodlots and man-made structures in spring to find host plants. There are exotic tree species common in woodlands and especially in more urban areas that are favored in the early season, especially Tree of Heaven. Later they will move into crop habitats, especially soybean fields, vineyards and orchards—almost anything that produces fruit, pods or nuts. Their movement appears to coincide with the development and maturity of seed pods and fruit in these crops. All tree fruits are attacked, but they especially prefer peaches.

In peaches and nectarines, adult feeding during bloom and shuck split can cause the fruit to abort. Feeding later in summer by adults or nymphs can cause a deep cat-facing injury such as that caused by tarnished plant bug (*Lygus lineolaris*) or depressed, dimpled, corky or water-soaked areas on the skin.

Stink bug adults have a broad, flattened, shield-shaped body and a narrow head. Adult BMSB are half-inch long by 5/8-inch wide, with a banded pattern

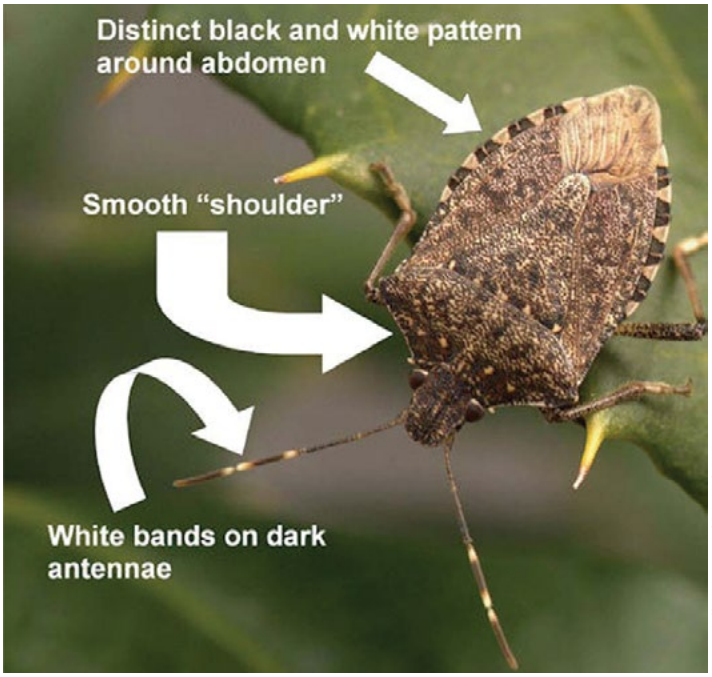


Photo: Jeff Wildonger, USDA-ARS-BIIR

Mike Haas, MSU Entomology

Brown marmorated stink bug nymphs on a peach.

along the margin of their abdomen and banding on their antennae and legs. They have smooth shoulders rather than toothed like some of our native species. Eggs are greenish-white in color and laid in a cluster of up to 28 eggs on the leaf underside of a preferred host. There are five nymphal stages. The first nymphal stage is black and red. The other four nymphal stages are brown like the adult.

All photos this page courtesy of MSU Extension

Adults blend in with this peach branch.

IPM steps for beginners

This is still a new pest outside of the Mid-Atlantic states, so if control is needed, time insecticides to kill immigrating adults as they appear in the orchards to prevent feeding damage and subsequent mating and egglaying.

In general, you will likely find the pest in the edges of an orchard. Use limb jarring over beating trays to help determine whether they are present. There are also commercial lures that can be paired with various traps to attract them for recording their number from week to week. Traps are best used between two habitats, like between a woodland and the crop of concern. Thresholds are still being developed in many crops that use these traps.

Ready for more precision

For more information on how to monitor and manage brown marmorated stink bugs, see Michigan State University Extension bulletin E0154 “Michigan Fruit Management Guide,” or stopBMSB.org.

Above and to the right are photos of a free-standing pyramid style trap. Traps are baited with an aggregation pheromone that attracts BMSB and then captures them in the clear top.

The Rescue brand trap is a pyramid style trap that must be attached to a tree trunk or post.

Chapter 31

Tarnished plant bug

Julianna Wilson, Michigan State University, Department of Entomology

Tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois)

Hosts

Peaches, nectarines, plums.

Time of concern

In spring and then again as fruit develop.

Damage, symptoms and pest cycle

Attacks most deciduous tree fruits. Pre-bloom stings on woody tissue or the floral peduncle leave a droplet of sap and often cause the abortion of flower buds. Stings at the base of the floral receptacle or on the fruit result in funnel-like depressions; fruit feeding in stone fruits can cause corky scars or catfacing injury.

The adult is brown and the extremities of its wings are translucent with a cream scutellum (triangular plate) on its back. The nymph is pale green; from the third nymphal stage, it has five black points on the back. It usually abandons fruit trees for alternate hosts soon after bloom.

Stinkbugs, other plant bugs and plum curculio can also cause catfacing injury. Catfacing injury develops after fruit is fed upon at an early stage when the fruit continues to grow and distort around the feeding site.

Bill Shane, MSU Extension

Catfacing injury on peaches.

Scott Bauer, USDA Agricultural Research Service, Bugwood.org

Tarnished plant bug adult.

IPM steps for beginners

Watch for presence of adults on buds. Eliminating alternate host broadleaf weeds in the orchard can contribute to management efforts, especially legumes, mullein, chickweed and dandelion, as well as pigweed, lambsquarters, plantain, goldenrod and aster.

Chapter 32

Occasional pests

Julianna Wilson, Michigan State University, Department of Entomology

Occasional pests

This factsheet describes several pests that are occasional problems in some years in some orchards.

Foliar and surface-feeding beetles

Rose chafer (*Macrodactylus* subspinosus (F.))

Japanese beetle (*Popillia japonica* Newman)

Hosts

Peach, but other stone fruit as well.

Time of concern

Summer.

Damage, symptoms and pest cycle

These beetles attack all tree fruits, particularly peaches and apples. Adults are the stage that cause damage when they feed on the fruit surface and leaves of deciduous fruit trees. The fruit may be partly peeled and gouged in irregular shallow patches or nearly devoured. The leaves are skeletonized. Damage is more severe in sandy locations, often occurring especially at orchard edges in proximity to grassy areas.

Rose chafer adults are slender, long-legged beetles, fawn-colored with a reddish brown head and thorax. The undersurface of their body is black.

Japanese beetle adults are metallic green or greenish bronze with reddish wing covers and several white spots near the tip of the abdomen and along the sides.

Larvae of both species are C-shaped grubs that live in soil in grassy areas and are not found on trees.

IPM steps for beginners

Feeding damage from adults is sporadic and transient during summer. If needed, apply an insecticide when leaf damage or the insects feeding on foliage are noted in the trees; retreatment may be necessary as new adults arrive. Biological control of beetle grubs can sometimes be accomplished through applying milky spores of bacteria or nematode products to adjacent grassy areas.

Mike Haas, MSU

Rose chafer adults.

Peter McGhee, MSU

Rose chafer damage on fruit.

A. Agnello, Cornell Univ.

Japanese beetle adult.

A. Agnello, Cornell Univ.

Leaves damaged by Japanese beetle adults.

Thrips

Frankliniella spp.

Hosts

Nectarine and other stone fruit.

Time of concern

During bloom and again during fruit ripening.

NRAES-75

Yellowish larva

Damage, symptoms and pest cycle

Thrips attack nectarines and other stone fruits. Adults infest developing fruit during bloom and again as the fruit ripens. Larval and adult feeding at bloom through shuck fall causes scars on the fruit surface that expand as the fruit grows. Feeding near harvest can result in a silvering or russeting of the fruit surface. High thrips infestations feeding on terminal growth can cause distortion of leaves and excess branching.

Western flower thrips, *Frankliniella occidentalis* (Pergande), and flower thrips, *Frankliniella tritici* (Fitch), are the two most common species and indistinguishable without a microscope. Adults are slender and yellowish with short antennae; the wings are long and narrow and held over the abdomen. Larvae are smaller and wingless, but otherwise resemble adults.

IPM steps for beginners

Injury tends to be more severe in orchards located in proximity to greenhouses and under drought conditions. Insecticide sprays may be necessary at petal fall and close to harvest.

Rosenberger

Feeding by thrips has caused silvering or russetting on the fruit surface.

San Jose scale

Quadraspidiotus perniciosus (Comstock)

Hosts

All stone fruit.

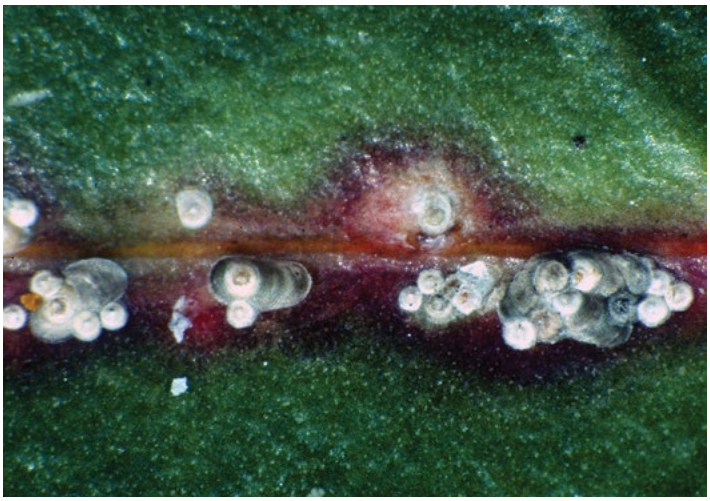
Time of concern

Dormant stage and again in early summer when crawlers are active.

Damage, symptoms and pest cycle

Scale infestations on the bark can be heavy and contribute to an overall decline in tree vigor, growth and productivity. Tree death is possible. Feeding on the fruit induces local red-to-purple discoloration around the feeding sites. Early-season fruit infestations may result in small, deformed fruit.

Adult males are minute, winged insects about 1 millimeter long and golden brown with a reddish tinge. Scales may be either disk-shaped (females) or oval (males), and are composed of concentric rings of gray-brown wax radiating from a tiny white knob. Nymphs (crawlers) are bright yellow and resemble spider mites.



J.A. Davidson, Univ. Md, College Pk, Bugwood.org

IPM steps for beginners

Spray a delayed dormant oil when buds are showing green tissue but before pink bud. Insecticide applications may be made to control newly emerged crawlers in early summer. Use pheromone traps to monitor adult males. A degree-day developmental model can predict crawler emergence after petal fall or trap biofix.

Lecanium scale (European fruit lecanium or brown apricot scale)

Parthenolecanium corni (Bouché)

Hosts

Peach and other stone fruit.

Time of concern

Dormant stage, and again in early summer when crawlers are active

Damage, symptoms and pest cycle

This pest attacks all deciduous tree fruits, particularly peaches. Female scales cover the undersides of twigs and are most noticeable during the dormant season. Crawlers feed on the leaves throughout summer and into fall, covering the fruit with honeydew on which a sooty black fungus grows.

The adult female scale is nearly hemispherical and shiny brown with several ridges along the back. Nymphs (crawlers) are light colored.

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IPM steps for beginners

Spray a delayed dormant oil when buds are showing green tissue but before pink bud to prevent eggs from developing under the scale covers; apply an insecticide when crawler hatch is complete, five to six weeks after peach petal fall. However, soft scales (family Coccidae) are usually controlled by a complex of parasitic wasps; this can be facilitated by avoiding disruptive sprays of broad spectrum insecticides.

Stone Fruit IPM for Beginners

http://bit.ly/stone-fruit-ipm

North Central IPM Center